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ORIGINAL ARTICLES.

I. — Some Account of a nearly complete Skeleton of *Hippopotamus Madagascariensis*, Guldb., from Sirabé, Madagascar, obtained in 1895.

By C. I. Forsyth Major, M.D., F.Z.S.

(PLATE XII.)

THE skeleton of a *Hippopotamus Madagascariensis*, Guldb., in the British Museum (Natural History) has been mounted from materials excavated by myself in the marshes of Sirabé (Central Madagascar) during the year 1895. The skull, lower jaw, several of the vertebræ, and presumably some other bones belong to the same individual.

My workmen reached a depth of five metres; the bones from which the skeleton is composed were found in the superficial deposit, but remains of *Hippopotamus*, apparently of a single species, are numerous at all depths.

We have a careful description of the skull and skeleton from the same locality by G. A. Guldberg,[1] and one by A. Grandidier & H. Filhol on materials collected by the former in the marshes of Ambolisatra on the south-west coast.[2] I myself have published some notes on the affinities of the Malagasy *Hippopotami* with the other then known species, living and extinct.[3]

There are in the British Museum (Natural History) rich collections from the interior and from the coast, which afford the materials for an exhaustive monograph of at least two of the three or four

[1] G. A. Guldberg, "Undersœgelser over en subfossil flodhest fra Madagascar": Christiania Videnskabsselskabs Forhandlinger, 1883, No. 6, pls. i and ii.

[2] Grandidier et H. Filhol, "Observations relatives aux ossements d'Hippopotames trouvés dans le marais d'Ambolisatra à Madagascar": Ann. Sci. Nat. Zoologie, ser. VII, vol. xvi (1893), pp. 151–190, pls. vii–xv.

[3] C. I. Forsyth Major, "On the general Results of a Zoological Expedition to Madagascar in 1894–96": Proc. Zool. Soc. London, 1896, pp. 976–978.

Malagasy species of the genus. As this work has still to be done, and as I do not care to give a compilation from the information already published, I wish the following lines to be considered merely as a brief explanatory note to accompany the figure of the mounted skeleton published in this number of the GEOLOGICAL MAGAZINE (Plate XII).

Remains of *Hippopotamus* from Madagascar, presumably from Sirabé, have been known for almost seventy years. In the Proceedings of the Geological Society of London[1] we find: "A letter was read from M. Telfair to Sir Alexander Johnstone, V.P.R.A.S., accompanying a specimen of recent conglomerate rock from the Island of Madagascar, containing fragments of a tusk and part of a molar tooth of a Hippopotamus, and communicated by Roderick Impey Murchison, Esq., F.G.S." These remains are preserved in the Museum of the Geological Society, the label accompanying stating them to come from a locality thirty miles from Antananarivo.

In 1867 M. A. Grandidier discovered remains on the south-west coast, to which in 1868 he assigned the name of *Hippopotamus Lemerlei*.[2]

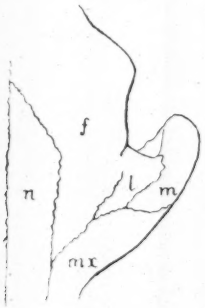

FIG. 1.—*Hippopotamus Sivalensis*, Falc. & Cautl. Frontal region; copied from fig. 3, pl. lix, Fauna Antiq. Sival.

f. frontal; *l*. lacrymal; *m*. malar; *mx*. maxillary; *n*. nasal bone.

Guldberg has compared the species from Sirabé with the living *H. amphibius* and *H. Liberiensis*, and comes to the conclusion that it occupies a somewhat intermediate position between the two, although approaching more closely to the former. I have formerly stated that all the Hippopotamus remains from Madagascar are certainly nearly related to each other, and this relationship may be briefly summed up as follows: In size they are intermediate between *H. Liberiensis* and *H. palæindicus*, with scanty indications of a larger form; in more important characters they would have to be placed, according to their greater or lesser degree of specialization, between *H. Sivalensis*

[1] Vol. i (1833), No. 31, p. 479.
[2] Comptes R. Ac. Sci. Paris, Dec. 14, 1868, vol. lxvii, p. 1165.

and *H. palæindicus* on one side and *H. amphibius* on the other; the lower end of the whole line being occupied by the most generalized form, *H. Liberiensis* of West Africa, the top by the most specialized, *H. major* of the Upper Pliocene of Europe.

The affinities thus expressed are based chiefly on the relative proportions of the cranial and facial parts of the skull, the former being greatly developed in *H. Liberiensis*, whereas in *H. amphibius* and in the *H. major* of the Upper Pliocene the cranial portion is much reduced, the facial portion on the contrary is enormously produced. The various crania from Madagascar have, in this respect, much resemblance to *H. Sivalensis*, the cranial portion, however, being somewhat shorter, the facial portion somewhat more elongate; so that the orbit occupies a less central position than in *H. Sivalensis* and, as a matter of course, still less so than in *H. Liberiensis*. "The Malagasy forms thus constitute a step farther in the direction of *H. amphibius*, the breadth of the intraorbital region being much less than in the African species and the same as in *H. Sivalensis*." [1]

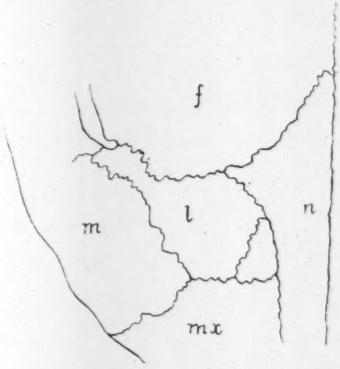

Fig. 2.—*Hippopotamus Madagascariensis*, Guldb. Frontal region of a skull from Sirabé, in the British Museum (Natural History).

f. frontal; *l.* lacrymal; *m.* malar; *mx.* maxillary; *n.* nasal bone.

These changes are reflected by the position of the lacrymal. In *H. Liberiensis* and *H. Sivalensis* (Text-fig. 1) the lacrymal is entirely separated from the nasal by the anterior prolongation of the frontal, which thus comes into contact with the maxillary; whereas in *H. amphibius* the lacrymal is usually broadly interposed between the frontal and maxillary.[2] I found long ago that the skulls from Sirabé exhibit in this respect also an intermediate position. As a rule, the lacrymal departs from the orbital margin in an inward direction and reaches the nasal, with which it broadly unites, thus shutting out the frontal from a connection with the maxillary.

[1] Op. cit., p. 977.

[2] See the exceptions in my paper, loc. cit., pp. 977, 978; and in Stehlin, Abhandl. Schweiz. Palaeont. Ges., vol. xxvii (1900), p. 434, footnote.

In front of the lacrymal, corresponding to the place which in *H. Liberiensis* and *H. Sivalensis* is occupied by the foremost tongue of the frontal, we find here a bone (Text-fig. 2) of varying dimensions, intercalated between the nasal and lacrymal, uniting with the maxillary in front, and sometimes reaching also the malar. In the skull of the figured skeleton the region under consideration presents the following conditions (Text-fig. 3). On the left side

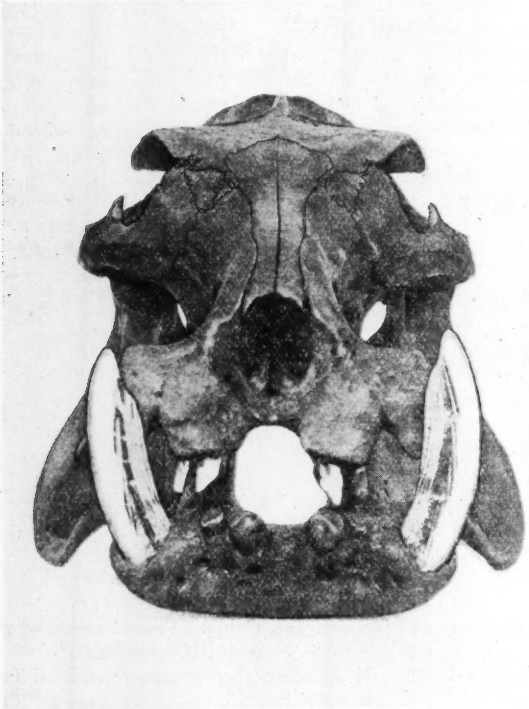

Fig. 3.—Front view of skull of *Hippopotamus Madagascariensis*, Guldb.

a short and narrow tongue of the frontal inserts itself between the lacrymal and nasal, where it meets with a similar but shorter prolongation of the maxillary. This is a stage slightly in advance of that figured by Falconer & Cautley in *H. palæindicus*[1]; in the latter the lacrymal is still very narrow, and the tongue of the frontal, though smaller than in *H. Sivalensis*, is still longer and broader than in the Malagasy skull. On the right side of the latter, two small supplementary bones are intercalated medially from the lacrymal; the posterior one is in contact with the frontal.

[1] Fauna Antiqua Sivalensis, pl. lvii, fig. 1.

nasal, lacrymal, and maxillary, the anterior with the lacrymal and maxillary, being separated from the posterior bone by a narrow prolongation of the lacrymal (see Text-fig. 3, right side).

During a visit to Paris several years ago, I pointed out to Professor Filhol the presence of a small intercalar bone between the nasal and lacrymal in one of the skulls from Ambolisatra; this has since been figured and discussed.[1] The bone being absent in the most generalized species of the genus, the name of prefrontal, which implies a homology with the so-called bone of lower vertebrates, appears to be unjustified; we have evidently to do in most cases with one (or more) Wormian bones. In some cases it may be simply an anterior prolongation of the frontal, the intermediate portion being covered by the expansion of the lacrymal.

Guldberg[2] has estimated the length of the *H. Madagascariensis* at 2·080 metres, assuming that the cranium is one-fifth of the length of the whole animal, as in *H. amphibius*. The mounted skeleton in the British Museum (Natural History) has a length of 1·95 metres.

I have elsewhere[3] stated that presumably "the Hippopotami entered Africa at a time when they were still in possession of all the characters of the Siwalik species, and that they crossed to Madagascar when they had reached a condition intermediate between *H. Sivalensis* and *H. amphibius*. In this condition they persisted in Madagascar, whilst on the neighbouring continent they progressed (or retrogressed) farther in the same direction." For reasons which I shall give farther on, we may assume to-day that Africa was the original home of the *Hippopotamus* tribe. But I see no reason to depart from the above statement as to their crossing over to Madagascar, presumably during the Pleistocene period. That the *Hippopotamus* persisted in the island up to a recent date, and was contemporary with man, may be assumed on the following grounds. Many of the remains are found in superficial deposits and present quite a fresh appearance. Grandidier & Filhol have figured[4] a femur from Ambolisatra, presenting two deep cuts evidently inflicted by man. At Sirabé the name of *Laliména* is given to the *Hippopotamus*, which my workmen recognized at once by the tusks, styled by them 'horns.' According to the legends of the inhabitants of the region, reported already by Dr. Borchgrevinck,[5] it was considered as the greatest exploit to fight the monster and deprive it of its 'horns.' This was termed to 'play' with the Laliména, and used to be the prerogative of the sons of the Betsileo kings.

It remains to add a few words on the presumed original home of the *Hippopotamus* tribe. Stehlin has pointed out in the skull of the chœromorid *Acotherulum*, from the Upper Eocene French Phosphorites, some features recalling decidedly the *Hippopotami*;

[1] Grandidier & Filhol, op. cit., p. 160, pl. viii.
[2] Op. cit., p. 24.
[3] Op. cit., p. 978.
[4] Op. cit., pl. xiv; see also p. 187.
[5] "Oversigt over Videnskabsselskabets Möder i 1882," pp. 8–11: Christiania Videnskabsselskabs Forhandlinger, 1882.

from this he argues that the latter may have been evolved from some member of the Chœromoridæ (very primitive pigs) nearly related to *Acotherulum*.[1] The later evolution of the *Hippopotami* must, however, have taken place outside Europe, since there is no trace whatever of ancestral *Hippopotami* in the Oligocene and the whole of the Miocene European deposits. The oldest known *Hippopotamus* is represented by scanty remains in the Lower Pliocene lignites of Casino (Italy); it was hexaprotodont like the Siwalik species, but more generalized than the latter in the shape of its molars.

Taking into further consideration the pigmy *Hippopotamus* (*Chœropsis*) *Liberiensis* from West Africa, a somewhat diverging lateral branch of the stem, which, according to Stehlin, has no relation with Asiatic and European fossil forms, he finally suggests that "possibly at the end of the Eocene, one of the Chœromoridæ, nearly related to *Acotherulum*, found a refuge in the Southern Continent [i.e. Africa], where during the Oligocene and Miocene periods it was gradually farther differentiated in the direction of the Hippopotamidæ."[2] This conclusion is very suggestive, especially when taken together with Andrews' recent discovery of the African origin of the Proboscidea. I wish to add that the Liberian *Hippopotamus has* affinity with the Lower Pliocene form of Europe, neither the one nor the other showing the specialized feature of a trefoil pattern so characteristic of the molars of *Hippopotamus* proper. Moreover, on account of the similarity of the lower canine and incisors of the Liberian '*Chœropsis*' with the same teeth of Cuvier's "*petit Hippopotame fossile*" (*H. minutus*, Blainv.), supposed to come from a locality in Southern France, Gervais has proposed for the latter the name *Chœropsis minutus*.[3]

This same species has of late been discovered in caves of Cyprus by Miss Dorothy M. A. Bate;[4] and for reasons stated in another place,[5] I have come to the conclusion that Cuvier's "*petit Hippopotame fossile*" was not found in France, but brought over from Cyprus. The *H. minutus* from Cyprus—which has little to do with the so-called '*H. minutus*' from Malta[6]—exhibits affinities with *H. Liberiensis*,

[1] Abhandl. Schweiz. Palaeont. Ges., 1900, pp. 433, 434.

[2] Op. cit., p. 488.

[3] Zool. et Pal. Gén., 1867–1869, i, p. 250.

[4] The ossiferous breccia at Chrysostomo, near Kythræa (Hagia Marina), in the district of Nicosia, which in Miss Bate's opinion must have originally been a cave, and from which she obtained the bulk of her collection, was, according to the account of the Dutch traveller Corneille le Brun (de Bruyn), well known in former times; the Greek inhabitants regarded and worshipped these *Hippopotamus* remains as the bones of their saints. (Corneille le Brun, "Voyage au Levant," etc., Delft, 1700, p. 375.) Le Brun figures (No. 193) a bone which he had worked out with great pains from the breccia, and says it resembles a human radius; but it can clearly be made out to be the femur of the *Hippopotamus*, represented from the posterior side and in two pieces, the larger fragment being the proximal, the smaller the distal portion.

[5] At the meeting of the Zool. Soc. of London, April 15th, 1902.

[6] For this Maltese species, which is intermediate in size between *H. Pentlandi* and *H. minutus*, and differs besides from the latter by exhibiting the characteristic trefoil pattern of the molars, I accordingly propose the new specific name of *Hippopotamus Melitensis*.

not only in its canines and incisors, but in its molars as well; they are of an even more generalized character and closely approach to those of the Casino form, though being of still smaller size.

In my opinion, therefore, this Pleistocene insular form is a slightly modified survivor of Tertiary Hippopotamidæ, as is also the recent *H. Liberiensis*—the latter, by the way, a parallel to that other early type, the *Ocapia*; the former points out the road, or one of the roads, by which the *Hippopotami* may have passed from Africa to more northern regions, before Cyprus was severed from its connection with the neighbouring continents. There are therefore good reasons for supposing that the Oligocene and Miocene ancestors of the *Hippopotami* had their home in Africa.

The assumption of a, geologically speaking, recent appearance of the *Hippopotami* in Madagascar is based on the more modernized characters of the Malagasy *Hippopotami*, as compared with the Pliocene members, with *H. minutus* and with *H. Liberiensis*, which characters place the first-named nearer to *H. amphibius*.

II.—On a Sodalite Syenite (Ditroite) from Ice River Valley, Canadian Rocky Mountains.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

In the year 1886 the late Dr. G. M. Dawson gave an account[1] of a syenitic rock, rich in a beautiful blue sodalite, which he had discovered when exploring the district near Hector Pass, on the watershed of the Canadian Rocky Mountains, and an analysis of the mineral was afterwards published by Professor Harrington.[2] The place was visited last Summer by Mr. E. Whymper during his examination of the district south of the Canada Pacific Railway, when he collected a number of specimens, which he showed to me on his return. The rock is hardly less beautiful than lapis lazuli, and as no description of its microscopic structure has been published, as far as I can ascertain, I give the results of my examination, together with a condensed account of its mode of occurrence. I am much indebted to Mr. Whymper for placing his specimens at my disposal, to Mr. L. Fletcher, Keeper of the Mineral Collection in the British Museum, for the opportunity of examining specimens of sodalite rock not in my own cabinet, and to Mr. L. J. Spencer, of that department, for giving me his kind assistance and valuable references to papers about the mineral.

Dr. Dawson states that the Beaver-foot Range, on approaching the Kicking Horse River,[3] becomes bordered by rounded and wooded hills, composed of slaty Cambrian rock, which, so far as can be

[1] "Physical and Geological Features of that portion of the Rocky Mountains between lat. 49° and 51° 30'": Geol. and Nat. Hist. Survey of Canada, 1885, p. 122, B.

[2] Trans. Roy. Soc. Canada, vol. iv, sect. iii, p. 81.

[3] Hector Pass, by which the Canada Pacific Railway crosses the watershed of the continent, was formerly called Kicking Horse Pass.

observed, underlie the valley, but that on the opposite side of this the centre of the high range is formed of an intrusive series of syenitic rocks, which he examined on Ice River, where they were well developed; and he continues (p. 122, B), "here the latter are first seen about two miles up the valley from the south-western base of the mountains at its entrance." Those on the east side of the valley are entirely composed of syenite, and further up those on the opposite one, as well as (apparently) those at its head; and the same mass is continued southward at least as far as the head of the Beaver-foot. It is newer than the slaty Cambrians, but posterior to their cleavage; this is lost as the rocks approach it, while they are baked and porcellanized. "The intrusive mass itself, though very varied in appearance in different places, is in the main a nepheline-syenite. The form most abundantly represented is a medium- to coarse-grained crystalline rock, composed of felspar, nepheline, and hornblende in varying quantities, with grains of magnetite and some crystals of sphene. The colour generally varies from pale grey to dark grey, becoming nearly black in places when the hornblende greatly preponderates. In such black varieties sphene is particularly abundant. The crystals of the component minerals are occasionally nearly an inch in length, while in rare instances they become almost cryptocrystalline. Other specimens derived from the same occurrence, but found as boulders in the bed of the torrent, have a banded and almost gneissic aspect, and under the microscope prove to contain numerous grains of quartz.[1] . . . . As far as I was able to determine, the mass appears to have been much disturbed, and as it were kneaded together while in a plastic or semi-plastic state. Portions of it have become brecciated and are recemented by similar material, differing only in texture or colour. Veins and crevices, which have evidently been filled by segregative action, also occur, and in these minerals similar to the main mass are developed; but with them, in considerable abundance, sodalite of a beautiful ultramarine-blue colour is found. In the same veins crystals of ilmenite were observed." After referring to Dr. Harrington's analysis of the sodalite (given below) he continues: "It much resembles lapis lazuli in appearance and would have considerable value as an ornamental stone. It is not confined to a single part of the intrusive mass, as it was found to occur in fragments brought down from the mountains further south in the bed of the Beaver Foot."

Mr. Whymper informs me that the Ice River Valley lies in the mountain mass to the south of the Canada Pacific Railway, where it descends in a south-western direction from the summit of Hector Pass to a place called Leanchoil. About three miles south of this the Kicking Horse River is joined by the Beaver-foot River, coming from the south-east, into which the Ice River has already emptied itself; this also follows a general south-west course, thus rising

[1] This mineral, as it happens, does not occur in the specimens which I have examined.

in the neighbourhood of the watershed of the Rockies. On its left bank the mountains (nepheline-syenite) form fine craggy peaks and a rocky cirque around its head. Their lower slopes are buried under débris, though here and there furrowed deeply by glens descending from the gaps between the peaks. In one of these, coming into the lower part of Ice River Valley, Mr. Whymper discovered the sodalite rock *in sitû* at the foot of a little crag, though even here it did not outcrop at the surface, but had to be exposed by digging away the débris, which prevented him from studying its relations with the nepheline-syenite. He also found loose pieces of the sodalite rock all the way to the head of Ice River Valley and in the principal lateral glens; so it must occur among the crags, no doubt in a vein-like fashion, in not a few places.

He brought away numerous specimens, though many of them were small in size. These are generally coarse-grained, sodalite and felspar being the dominant minerals. They also contain a little of a dull darkish-green mineral, an occasional small flake of brown mica, and a grain of pyrite. Nepheline may be among the felspar, but of that, so far as megascopic examination goes, I am doubtful. The sodalite is a rich blue, deeper in tint than ultramarine, occasionally almost a 'royal blue.'[1] The felspar is more or less cream-coloured. The structure of the rock is variable. Sometimes the sodalite is associated with the felspar, much as that mineral is with the quartz in a fairly coarse, almost binary granite. Sometimes the two are less uniformly distributed, so that the rock has a coarsely mottled look, and sometimes sodalite practically pure is streaked or veined by almost pure felspar, or *vice versâ*; the latter perhaps forming the more regular bands, which may be nearly an inch in breadth. But in a single fragment, a dozen square inches or so in area, the one type of rock may be seen to pass insensibly into the other. The specimens have led me to the conclusion that the rock originally consisted of a very irregular, often streaky mixture (such as may be seen in some 'pegmatite' veins) of felspar and sodalite or another mineral now represented by it, and that, though it shows some signs of fracture, it is not a brecciated mass of felspar cemented by sodalite.

Sodalite of a rich blue colour occurs associated with felspar at Dungannon and Faraday, in Hastings Co., Ontario. According to the description of Professors F. D. Adams and B. J. Harrington,[2] the country rock is a nepheline-syenite, which occasionally is extraordinarily coarse, for the crystals of nepheline[3] are said to be sometimes over two feet long, and the felspars of corresponding size, the latter, according to Professor Adams, being all plagioclase. The

[1] Mr. Whymper found a few specimens where the mineral was a pale blue.

[2] Amer. Journ. Sci., vol. xlviii (1894), pp. 10 and 16; see also vol. xlix (1895), p. 465.

[3] Professor Harrington thinks the term elæolite needless, for no line can be drawn between the specimens with the more oily and the more glassy lustre. So far as I have had the opportunity of judging, the distinction can hardly be maintained.

sodalite, of which Professor Harrington gives an analysis, occurs in streaks and irregular masses in the nepheline-syenite, the largest mass measuring about 10 × 10 × 4 inches. These are traversed by a few little veins of a white and reddish felspar, which on analysis is found to contain $K_2O = 12{\cdot}08$ and $Na_2O = 3{\cdot}67$, and thus to be a soda-orthoclase. Small scales of dark-brown to black mica occur in the sodalite. The constituents of the nepheline-syenite are plagioclase, nepheline, and either brown mica or dark-green hornblende; scapolite and calcite are accessories, seldom absent but never abundant, also sodalite, garnet, zircon, apatite, magnetite, and pyrite. Nepheline is the most abundant constituent; the plagioclase is albite, but with a small proportion of lime; the hornblende (probably rich in soda) shows fairly good crystalline outlines and characteristic cleavage; the calcite occurs like an original constituent, which is possible, as the rock is intrusive in limestone.

The specimen from Hastings in the British Museum is very like those brought by Mr. Whymper from the Ice River. A similar rock is found in boulders at Coburg on the north shore of Ontario. The same collection contains blue sodalite in a generally similar rock (with a vein of yellowish cancrinite) from Litchfield, Canada, as well as in the familiar Ditroite of Ditro (Transylvania) and Miascite from Miask in the Ilmen Mountains,[1] at Thorstrand, near Laurvig, and at Brevig, Norway, both of which have some resemblance to the Ice River specimen. The interesting variety from Lake Baikal[2] is massive, granular, and a rich dark-blue colour. A blue sodalite is found less abundantly in a rather compact brownish-grey rock at the Montreal Reservoir and at Heidelberg near the same city. Here it occurs in spots, which are often bordered by a white variety, and suggest filled up cavities. The mass of the rock is rather decomposed, but felspar and nepheline with the general structure of a phonolite can be recognized. Probably it would now be called a Tinguaite.[3]

Examination of slices cut from the Ice River Valley specimens shows the felspar to be imperfectly idiomorphic, with a slightly 'dusty' aspect, due to incipient decomposition. Most of it with crossed nicols exhibits a composite structure, with a minute acicular intergrowth or a colour mottling, the remainder having the twinning of plagioclase, though even here the components are rather more spicular in form and less sharply defined at the edges than is usual.[4] They evidently represent the peculiar group—perthite, soda-orthoclase, anorthoclase, and other plagioclases—so common in rocks exceptionally rich in soda, such, for instance, as are figured by Fouqué & Lévy[5] in the well-known rocks from Miask and Ditro and the elæolite-syenite from Brevig, except that I have not met

[1] As these rocks are practically identical, one of the names should be dropped.

[2] Described by Brögger and Backström: Zeitsch. Kryst., vol. xviii (1890), p. 222.

[3] For sodalite rocks in general see Rosenbusch, "Elemente der Gesteinlehre," 1898, pp. 115, 131. A most lucid description of the mineral sodalite is given by Fouqué & Lévy, Mineral. Micrograph., 1879, pp. 447–450.

[4] The extinction angles, measured from the composition edge, are rather small.

[5] Mineralogie Micrographique, pl. xlv, figs. 1 and 2.

with such a definite microcline as is represented in a slice from the Hungarian locality.

The sodalite occurs in irregular patches, sometimes of considerable size,[1] and in veins, these being sometimes very minute. It is generally water-clear and in very good condition, though occasionally it has a slightly dusty look or is traversed by a line of filmy microliths, giving bright tints with crossed nicols, probably due to incipient decomposition along minute cracks. In some parts the sodalite is a mass of small, tolerably well-formed hexagons (sections of dodecahedral crystals), ranging about ·003″ in diameter; in others they may be even ·2″ or ·3″ broad, but their outline then is less distinct; the first occasionally forming a kind of 'strait' in the second or filling little cracks in the felspars.

Pyroxene is represented by small patches, generally few in number, of a dull green, often muddy in aspect, tending, at any rate towards the ends, to become acicular or to form groups of little parallel prisms, an acicular microlith occasionally occurring; the clearer specimens show a faint pleochroism, the extinction angles are rather small, and the mineral is a rather light green by reflected light, so it is probably a soda-hornblende. It almost always occurs in association with the felspars. The specific gravity of a specimen with a little more pyroxene than usual is 2·58.

Zircon: two or three very minute enclosures may be this mineral. The occurrence of nepheline is doubtful, so is apatite, and iron-oxide is not present in the slices which I have examined.

Besides these specimens of sodalite syenite Mr. Whymper brought some fragments from other boulders in the Ice River Valley. One of these is a rather compact rock of a grey colour with a slight tinge of green, in which are scattered occasional elongated crystals of felspar, nearly ·3″ in length, and (more abundantly) similarly shaped dark hornblendes, the largest being about as long; both minerals, but especially the latter, lying more or less in parallel order. Under the microscope the rock is found to contain the following minerals:— (1) Felspars, in fair preservation; some apparently idiomorphic, others irregular in outline, the majority ranging from ·1″ to ·2″ in longer diameter, but occasionally about half-a-dozen granules less than ·01″ are associated between the larger grains; these mostly exhibit the peculiar mottled perthitic structure common in felspar-elæolite rocks, with a little plagioclase. (2) Nepheline, in characteristic and good preservation; sometimes in rather imperfect prisms, sometimes interstitial between the felspars, from which I conclude that the two minerals crystallized almost simultaneously. (3) Hornblende: the megascopic crystals already mentioned exhibit a moderately perfect crystalline outline, but are a little ragged at ends and edges; besides this they are locally fringed with independent granules of the same mineral. Both are pleochroic, the former changing from a rich brown to a very dark tint of the same, which towards the outside is occasionally tinged with green;

[1] I have a slice, practically all sodalite, about 1 inch long and rather less in breadth.

the latter sometimes showing only a change in a green tint, but occasionally passing from a fairly strong green to deep brown. I have not found an extinction angle exceeding 12°. The larger crystals include sphene, and once or twice a small grain of felspar. (4) Sodalite, not abundant or blue; in little interstitial patches of granules. (5) Sphene, rather abundant; obviously the first mineral to consolidate, for it is idiomorphic, and is included by or penetrates the hornblende. The specific gravity of this specimen is also 2·58.

Two small fragments "from boulders" are varieties (not quite so well preserved) of a similar rock, but are more gneissic in structure and contain, especially one of them, rather more dark pyroxene. Examination of thin slices shows three forms of this mineral: a slightly pleochroic (green to pale brown) augite, probably ægirine, a brown hornblende, and a green one (both as described above). The third seems formed from the second, but in one case also from a puce-brown augite (? titaniferous). A more normal orthoclase is common among the felspars, but microperthite and plagioclase are found. Nepheline is much less abundant than in the last specimen, but certainly occurs. There is a little sodalite, once or twice seeming to fill a crack, a grain or two of iron-oxide, some apatite, and a fair amount of sphene, these two being the first to form.

The fourth specimen has a dark-green groundmass, slightly mottled with a paler tint (which becomes yellowish-white on a weathered surface). In this are scattered grains, a little more than ·3″ in diameter, of a brownish-black pyroxene, with slight traces of a lustre-mottling. A slice proves the constituent minerals to be (1) a pleochroic augite, changing from a pale brownish-yellow to puce brown (probably a titaniferous variety), showing locally a diallagic habit by small dark parallel lines or rods, which when highly magnified appear a deep brown colour; a second set, making a large angle with these, being sometimes visible. (2) A green pyroxene in fair-sized grains, which, however, show a mottled or composite structure, probably a further stage of change. (3) A strongly pleochroic hornblende, changing from warm brown to deep brown. The relation of these pyroxenes is not easily determined. Sometimes a small grain of the augite seems to be included in the hornblende, sometimes the two lie side by side with a sharp line of demarcation, the crystals in each case having different orientations; but sometimes films or spots of the brown hornblende are connected either with augite of similar colour or with the green aggregate, as if formed from them. The brown augite is occasionally composite in structure, so I incline to regard these as a series of changes of which the brown hornblende is the last. (4) Iron-oxide: generally associated with the pyroxene, and later in consolidation, often enclosed in a very narrow, clear, composite border. (5) Apatite: very characteristic and rather abundant, generally containing some dusty material. (6) Nepheline, in irregular grains, acting as a sort of matrix to the pyroxene, containing sometimes minute colourless needles, and not seldom films similar to those already mentioned in

connection with sodalite. (7) Felspar: doubtfully present, but may be represented by one small grain at the edge of the slice. (8) Sodalite: a little, very local in occurrence. It contains a few colourless belonites, and is associated with elæolite in a way strongly suggestive of a partial replacement of that mineral. (9) Sphene: two or three fair-sized grains, including apatite, and in one case pierced by a brown augite, may be either this mineral or (possibly) another variety of augite. Thus the rock, which has a specific gravity of 3·12, is more nearly related to the nepheline-dolerites than to the nepheline-syenites.

These specimens, especially the former, Mr. Whymper tells me may be taken to represent the country rock in which the masses rich in sodalite occur.

He also brought a flake-like specimen of fibrous actinolite and a fragment consisting of bits of a pale dull green chloritic or hornblendic rock, cemented with quartz, obviously from a vein.

One more specimen, though interesting in itself, has no direct bearing on the present investigation. It is a darkish grey rock of slightly foliated aspect, which on microscopic examination proves to consist of granular calcite and rather elongated prisms of tremolite (occasionally also in needles). Dusky patches of blackish granules occur in both minerals, but especially in the former, and very minute, rather filmy microliths are included in the latter. I do not remember to have seen a rock quite of this type before, but think it may be a result of contact-metamorphism.

What, then, is the history of the sodalite in the Ice River Valley rock? Is it an original constituent or of secondary origin? Sometimes it occurs in interstitial patches among the other minerals; sometimes it fills up cracks in the felspars. The first suggests an original constituent; the second must have formed after consolidation in fissures due to strain. But even in the former, sodalite may have replaced some other mineral, and in the latter obtained materials from it. Professor Harrington's analysis of the Ice River sodalite (rearranged by Dana in "System of Mineralogy," 1900) shows it to be remarkably pure:—

SiO_2	Al_2O_3	Na_2O	K_2O	Cl	
37·50	31·82	25·55	0·27	7·12	= 102·26

Typical analyses (see Dana) of this and two related minerals are:

	SiO_2	Al_2O_3	Na_2O	K_2O	Cl	Total.
Sodalite	37·2	31·6	25·6	—	7·3	101·7
Nepheline	44·0	33·2	15·1	7·7	—	100
Albite	68·7	19·5	11·8	—	—	100

If, for purposes of comparison, we reduce the Al_2O_3 (as the most stable constituent) to unity, we have:—

	SiO_2	Al_2O_3	Na_2O	K_2O
Sodalite	1·17	1	·80	—
Nepheline	1·32	1	·45	·23
Albite	3·52	1	·60	—

Thus, in forming sodalite like that of the Ice River from

nepheline,[1] a certain amount of potash and of silica must be removed, and ·35 of soda added with the chlorine, an operation not difficult for heated water with a fair amount of sodium chloride in solution. To obtain it from albite, only ·20 of soda would have to be added with the chlorine, but 2·35 of silica, a rather large amount, must be removed. In the case of the Ice River rock (and not in this alone) I believe the larger patches of sodalite to have mainly replaced nepheline. At the same time I think it has, to some extent, also replaced a soda-felspar; small irregularly outlined bits of the latter, with a rather 'residual' aspect, are enclosed in the sodalite, especially near to its outside; the edge of the felspar also, where the two are in contact, seems to be a little corroded.[2] It is also evident, from its occurrence in the minute cracks, that some of the sodalite, especially that in the small dodecahedra, has been deposited from a state of solution. So I believe the sodalite to be a mineral of secondary origin in the principal cases mentioned in this paper, without, however, disputing that in some others it may be an original constituent.

III.—Notes on the Geology of Perim Island.[3]

By Catherine A. Raisin, D.Sc.

I AM indebted to Mr. J. A. Rupert Jones (Lieut. R.N.R.), now at Aden, for a series of rock specimens collected and sent from Perim Island, accompanied by notes and diagrams. From all these I have drawn up a short preliminary account, since they illustrate some points of interest, and no complete description of the geology of the island, as far as I know, has been published.

I. General Description.

Perim is a rocky barren island about 3 miles in length at the entrance to the Red Sea, bounded on the east by the "small strait," 1½ miles broad, and on the west by the "larger strait," 9 to 10 miles across. It is roughly of a horse-shoe shape, surrounding a harbour opening to the south. Low plains below the 12 feet contour-line, evidently raised beaches, form much of the island (perhaps one-half or more), extending inland, especially at the north. The neighbouring sea is shallow, the 5 fathom contour-line bending into the harbour, the 10 fathom line extending outside the harbour to the south and around a large submarine plateau to the north. A narrow depression begins in the broader strait, and, after an interval, recommences further north and extends almost the whole length of the Red Sea, sometimes over 1,000 fathoms deep[4]—the whole resembling a submerged valley with abrupt sides.

[1] Fouqué & Lévy (loc. cit.) remark that the chemical formula of sodalite (allowing for the chlorine) is identical with that of nepheline. They and Rosenbusch (loc. cit.) allow that it may be a secondary mineral.

[2] Morozewicz made sodalite artificially by fusing kaolin or nepheline with soda and excess of sodium chloride; see Journ. Chem. Soc., vol. lxxvi, pt. 2 (1899), p. 764.

[3] An abstract of this paper was read at the British Association Meeting, Glasgow, 1901.

[4] The above depths are taken from the Admiralty Chart.

The islands in the Red Sea and the hills beyond the low coast plains are sometimes of sedimentary strata (e.g. Nubian Sandstone), sometimes of volcanic rock (as in Ketumbul, Jebel Teir). Other hills are of Archæan gneiss, while many islands are coral reefs or formed of coral, and calcareous sediment must be often deposited.[1]

Above the 12 feet contour-line, the island of Perim is hilly, rising to 249 feet at the highest point. The foundation rocks of the island are exposed in cliffs and quarries, and all the specimens sent are volcanic. The surface of the island, to a depth generally of about 7 feet, consists of irregular blocks, sometimes as much as 4 feet in diameter, imbedded usually in whitish calcareous sand or mud, and coral is common in the adjacent sea.[2] As described by Mr. Rupert Jones, the surface of the island has only to be rolled down when damp (the big blocks being removed) to set into a hard, smooth cycle track.

II. Petrological.

1. *Rocks in situ:* (1) *Basalts.*—Two specimens from the cliff to north-east of Balfe Point, west of the island, were taken from two bands each about 12 feet thick. The rock is compact, dull brown, mottled with paler brown, splitting with a slabby or platy structure, which is more marked in the upper band. The lath-shaped microliths of plagioclase felspar exhibit a definite orientation, and are imbedded in a small amount of glassy base, with black granules and grains of iron oxide, small crystals of pyroxene, and a few rather larger crystals (usually pyroxene or felspar). Thus it is a not very basic magma basalt, approaching an andesite, and is probably a lava-flow.

In several of the Perim rocks two apparently ferro-magnesian minerals are found. One is augite, very pale greenish with low polarization tints; the other is in well-formed crystals, partly or wholly a reddish brown. The central part of these, when it is clear, shows rich polarization colours, has no cleavage, is rather granular, and sometimes contains enclosures. The mineral resembles olivine, but it might be a second pyroxenic constituent, and gradations from undoubted augite sometimes occur. In a few slides it constitutes microporphyritic crystals, but such crystals (few and small) more generally consist of felspar.

Another rock (from a cliff north-east of the harbour) is dull purplish red, mostly compact, rather coarser-grained than the last described, and without fluxional orientation. It contains one group of larger crystals, consisting of felspar (with glassy inclusions along crystal planes) and of augite.

(2) *Volcanic Tuffs.*—In a quarry east of Balfe Point (Fig. 1), some 25 feet deep, the basement rock, a layer about 1 foot thick, is whitish, mostly fine-grained, but with occasional fragments up to $\frac{1}{2}$ inch in diameter, weathers to a crumbling mass, but probably would set into a hard stone. Crystalline calcite, sometimes in

[1] At one spot, in the north of the Red Sea, a recent accumulation of oolitic grains was described by J. Walther, "Die Korallenriffe der Sinaihalbinsel," 1888.

[2] Marked on the Admiralty Chart.

definite rhombohedra, cements the grains and fills the vesicles. The material is chiefly pumice, but some fragments are a glass basalt. Broken crystals also occur of felspar, often plagioclase, of green hornblende, and brown-stained augite or olivine. One or two fragments exhibit perlitic cracks, and one, partly devitrified, has a radiating structure. Above this tuff occurs a fine material described as 'sand,' looser above, becoming harder below, but the character of an imbedded nodule suggests that the deposit is a fine volcanic dust.

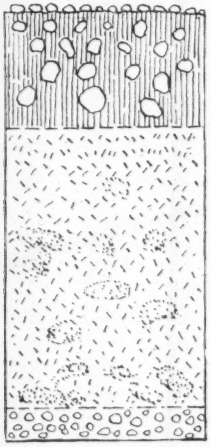

FIG. 1.—Section in a quarry east of Balfe Point.

A. Blocks of lava, described as imbedded in coarse calcareous sand.
B. Fine material resembling 'sand,' contains concretionary felsitic nodules, and is probably a fine trachytic ash.
C. White pumiceous tuff.

The nodule is roughly cylindrical, hard, pale brownish, and consists of felsitic fragments mostly sub-rotund, with a few angular chips of minerals like those in the underlying tuff. The pieces are crowded close together, cemented by an isotropic substance which is mammillated in form, and in the broader spaces passes to chalcedony; it is doubtless opaline silica. Thus originally fragments of the viscid lava were thrown down which solidified in cryptocrystalline condition, sometimes as a mere rim around a broken crystal; and a deposit of silica cemented the fragments.

2. *Surface Blocks.*—Specimens of these have been taken loose from many localities, and others from the two sections examined near the west of the island. In the section to north-east of Balfe Point calcite fills veins and cracks, few and sparse in the lava beds already described, but becoming abundant above, while the surface deposit to a depth of 7 feet consists of blocks imbedded in fine calcareous mud. These blocks are mostly a red or dark brown, ropy, scoriaceous basalt, but one is composed of fragments and is probably a brecciated lava. Two blocks sliced for the microscope

are almost identical with the lavas below, except that they are more vesicular. In the quarry above the pumiceous tuff (Fig. 1) one block from the surface deposit is a very similar blackish basalt full of rounded vesicles. Not far from this spot were two loose specimens, a pipy scoriaceous basalt, and a bright red fine-grained tuff containing thin streaks of black glass with small spherulites. The latter rock consists of microscopic yellow-rimmed pieces of brown glass, minutely vesicular, or partly devitrified, even slightly spherulitic, with broken crystals of green augite and of felspar.

Other surface blocks from north of the harbour and east of the island are basalts or allied rocks. (*a*) One block (projecting from a coral or limestone conglomerate) has, especially on a weathered surface, the granular appearance of a rock with incipient spherulites. The microscope slice, however, is uniform, except for small slightly paler patches.[1] It consists of abundant glass containing minute felspars, and is probably a rather basic andesite. (*b*) Two blocks from further north contain a few vesicles, are almost a microcrystalline basalt with very little glassy base, both semi-ophitic. (*c*) A block from north of the harbour resembles the red lava from the adjacent cliff, but is a brighter colour and more vesicular. Others near consist of a black basalt with a few vesicles. (*d*) Various blocks further east are generally blackish, often compact, and of similar character.[2]

Thus the specimens from surface blocks are almost all basaltic, often vesicular and scoriaceous. They show at each locality a general resemblance petrologically to lavas occurring there *in situ*, where specimens of these have been obtained. Moreover, in the cliff section north-east of Balfe Point, we seem able to trace a gradual destruction of the underlying lavas through apparently brecciated layers to the surface deposit. Thus the surface blocks found generally over the island at different heights are probably more often disintegrated lava[3] than ejected fragments. In either case the blocks might have fallen into a sea where coral sand was accumulating, so that they would become imbedded in calcareous material. The low plains or raised beaches along the coast are frequently formed of a Recent limestone rich in large corals, Lamellibranchs, etc. I am indebted to Mr. Coomara Swamy for the loan of specimens from this rock, and also for a photograph representing the slope from which blocks of basalt, etc., might fall, to become imbedded in the limestone forming at the base. Even at higher levels, the calcareous material may sometimes represent sediment, often coral sand or mud, deposited during the gradual elevation of the island. The sea being shallow,

[1] I have found in other basalts or basic andesites (as in one from Auvergne) this appearance of incipient spherulites, which are not distinguishable on microscopic examination.

[2] Two slices lent me by Mr. Coomara Swamy, taken from blocks near here, are from very similar rock, but with the glassy base better defined and without the brown pyroxene.

[3] The disintegration of the rocks may have been helped by a rainfall greater in its amount in past times; and Mr. Jones remarks on the tanks built to hold water, now standing empty.

its waves and currents might exert some mechanical force.[1] Fine sediment would accumulate, and percolating water would deposit carbonate of lime. Secondary silica also occurs as in a flattened geode (about 3 inches long), lined with bluish mammillated chalcedony (resembling beekite), and in the opaline silica cementing the concretion in the section shown in Fig. 1.

III. Summary.

This district belongs to the extended volcanic area associated with the line of the Great Rift Valley. The abrupt descent of the bed in the Red Sea to a central channel may mark a part of that long depression, the form having been modified by later river action. The rocks of Perim probably correspond in age with the Aden basalts (the later volcanic period so named by Dr. Blanford), and they were doubtless emitted from some crater to the west of that at Aden. This ejected the material forming the pumiceous tuff of Perim, followed by the more abundant basaltic lavas. During depression and subsequent elevations of the land, the sea helped to carve out the straits of Babelmandeb and the gullies and rifts of the island. Coral reefs grew in the surrounding waters, and finally the raised beaches were formed, which record in Perim an uplift of at least 12 feet. The outline and depth of the harbour lend no support to the view that it marks an ancient crater, and the lavas and ashy beds which form the cliffs around it have generally a roughly horizontal direction. The indentation north-west of the harbour seems the end or continuation of a valley (containing the quarry of Fig. 1), extending from a raised beach here towards the raised beach near Balfe Point. Thus the present form of the land is mainly due to the usual forces of denudation and to oscillations of level, acting on an island built up of volcanic masses, within a shallow coral-bearing sea.

IV.—On the Correlation of the Palæozoic Rocks of South Africa.

By Walcot Gibson, B.Sc., F.G.S.

(*Continued from the April Number, p.* 165.)

THE ancient rocks of Prieska are extensively developed in Griqualand West, where they build up the elevated Campbell Rand plateau and the lofty ranges of the Langebergen Mountains situated to the west of the Orange River Colony. The order of succession, which is much disguised by faulting and folding, has been described in great detail by Mr. G. W. Stow,[2] whose descriptions render it evident that the rocks of these regions resemble the older strata which extend over such vast areas in the Transvaal.

Several attempts have been made to classify the ancient rocks of the Transvaal, the results being nearly as numerous as the observers. In his latest classification of the rocks older than the Beaufort

[1] One example is described where the boulders appear as if piled by the sea, forming a kind of island in the middle of the Birkhud Raised Beach to the north of Perim.

[2] Q.J.G.S., vol. xxx (1874), pp. 581 680.

Beds, Dr. Molengraaff arranges them in the following descending groups:—

TABLE OF STRATA BELOW THE BEAUFORT BEDS OF THE TRANSVAAL.[1]

KARROO SYSTEM.	**Ecca Series**	Shales and diabases.
	Dwyka Conglomerate	A coarse conglomerate of variable composition and of glacial origin.
	Great Unconformity.	
	Amygdaloid Rocks of the Boschveld (age doubtful).	
CAPE SYSTEM.	**Waterberg Sandstones**... ...	Sandstones, breccias, conglomerates, diabases.
	Plutonic Series of the Boschveld	Porphyroids, red granites, norites.
	Pretoria Series	Shales, quartzites, diabases.
	Dolomite Series	Cherts and dolomites.
	Black Reef Series	Sandstones, quartzites, shales, and conglomerates.
	Great Unconformity.	
PRIMARY SOUTH AFRICAN SYSTEM.	**Amygdaloid Rocks**	Diabases, amygdaloidal lavas, porphyrites.
	Ancient Granite Series... ...	Grey granite.
	Barberton, Hospital Hill, and Witwatersrand Series ...	Schists, quartzites, gold-bearing conglomerates (Banket).

This table embodies the results obtained by Dr. Molengraaff during several excursions undertaken in the years 1898 and 1899 with the object of a future systematic study of the region, and is by far the most complete of any yet produced. Dr. Molengraaff's classification differs from nearly all others by including the Banket formation in the Primary South African System,[2] instead of considering it to be the northern equivalent of the Table Mountain Sandstone. Dr. Molengraaff further differs from many observers in regarding the granites and gneisses cropping out between Johannesburg and Pretoria and round Vredefort as intrusive into the Hospital Hill Series, whereas they have generally been considered to belong to a much older Archæan massif in which the gold-bearing rocks have been enfolded by earth-movements. Which view is correct can only be satisfactorily determined by systematic mapping. In the meantime it is of more service to draw attention to the results obtained in mining and especially from an examination of the area immediately round Johannesburg, of which considerable information has been obtained of late years.

Soon after the commencement of the gold industry the auriferous rocks were believed to be arranged in a unicline, comparable with an English coal-basin. In 1892 it was shown,[3] chiefly from observations from surface outcrops, that overthrusting had taken place to a considerable extent, possibly disguising the succession and certainly causing much repetition. Since then the progress of mining, and especially the development of 'Deep Levels,' has conclusively proved the existence of several overthrust faults of considerable vertical displacement, resulting in the duplication at the

[1] Dr. G. A. F. Molengraaff: Bull. Soc. Géol. France, 1901, ser. IV, t. 1.
[2] See also W. Gibson: GEOL. MAG., Dec. IV, Vol. IV (1897), pp. 548–550.
[3] W. Gibson: Q.J.G.S., vol. xlviii (1892), pp. 404–437.

surface of some of the reefs. The powerful effects of these overthrusts have been further demonstrated by the presence of shearing on the edges of the igneous dykes which are frequently situated along thrust planes; and also by the conversion, by dynamic action, of the smaller dykes into hornblendic and chloritic schists.[1] Minor movements are indicated by a conglomerate band known as the Main Reef Leader, being so firmly attached to the overlying quartzite that the reef is described as 'frozen' into it, while the footwall or underlay consists of a band of soft schist accompanied in many places by a vein of secondary quartz. These phenomena suggest a minor thrust plane coincident with the footwall. That this is so becomes more apparent in the Spes Bona Mine, where on the third level the conglomerate band known as the Main Reef is brecciated and is separated from the Main Reef Leader by eight feet of quartzite; while on the fourth level the two reefs are separated by a wedge-like mass, 40 feet wide, composed of a rock looking like a hard siliceous mudstone.[2]

Major thrusts have not been definitely proved underground, but there is little doubt that a dislocation of this nature separates the Hospital Hill Series from the Witwatersrand (Banket) Beds, as has been frequently described and figured since its existence was pointed out in 1892. Another major thrust of great intensity is indicated by the junction of the Hospital Hill Series with the granites and schists north of Johannesburg, where the two formations are so altered by dynamic action along their junction that all trace of a line of demarcation disappears (Molengraaff, op. cit., p. 20). The disposition of the quartzite ridges of the Hospital Hill Series north of Johannesburg and their progressive metamorphism as they approach this major thrust, taken in conjunction with their apparent great thickness, 8,000–10,000 feet,[3] strongly suggests that the various quartzite beds and intervening shales are due to duplication or even reduplication by overthrusting. Dr. Molengraaff denies the existence of anything more than a local duplication, though he acknowledges (op. cit., p. 22) that the "orogenic movements from south to north have been very energetic against the granite massif, which plays the part of a buttress."

Whatever may be the extent of the overthrusting, it is evident that the simple basin theory does not receive the support of recent investigation. The theory was mainly deduced from the generally observed decrease in the inclination of the reefs when followed in the direction of dip. It now appears that a secondary steepening of the dip has an extended occurrence along the Witwatersrand. This is most marked in the Simmer and Jack Mine, where from the 3rd to the 4th level the dip is 10° 40′, from the 6th to the 7th level 0° 30′, from the 10th to the 12th level 37°, and from the 14th to the 16th 29° 35′.[4] How vastly important to the future of the

[1] F. H. Hatch: Q.J.G.S., vol. liv (1898), p. 85.
[2] S. J. Truscott: "The Witwatersrand Goldfields; Banket and Mining Practice," 1898, p. 109.
[3] F. H. Hatch: op. cit., p. 79.
[4] S. J. Truscott: op. cit., p. 13.

gold-mining industry overthrusts will prove by counteracting the effects of this secondary steepening, is at once apparent.

In the group of rocks succeeding the Witwatersrand Beds Dr. Molengraaff finds a fancied resemblance to the sequence from the Table Mountain Sandstone and succeeding beds; the Black Reef Series, Dolomitic Series, and Pretoria Series being compared by him with the Table Mountain Sandstone, Bokkeveld Beds, and Witteberg Series. The dolomite in the Transvaal is unfossiliferous, while the Bokkeveld Beds contain a rich fauna of a Devonian facies. The dolomite most resembling that in the Transvaal is the rock in the Cango district, where, as previously stated, it is probably in an inferior position to the Table Mountain Sandstone. In Cape Colony the Witteberg Beds pass up conformably into the Dwyka Conglomerate; in the Transvaal the Glacial Conglomerate is markedly unconformable to the Pretoria Series. The resemblance, therefore, between the two colonies does not seem very exact. Regarding the unfossiliferous nature of the Transvaal older rocks, and the movements to which they have been subjected, it seems futile to attempt a correlation with the undetermined succession at the Cape; while to draw any comparison with the European Palæozoic rocks, as is frequently done, is *a fortiori* valueless deductive reasoning.

Of the older rocks of Rhodesia, Zululand, and Natal the information is scanty. It appears that the Bokkeveld Beds, or at any rate strata containing the Bokkeveld fossils, die out before they reach Natal, just as they do in the north-west provinces of Cape Colony. A fact in favour of their being unrepresented in the Transvaal.

To briefly summarize the knowledge of the older stratified formations in South Africa. The geological record is very imperfect. There are many rock groups, but excepting the Bokkeveld Beds at the Cape their age has not been determined. There are no certain representatives of strata of Silurian, Ordovician, and Cambrian ages. South Africa, then, appears to be the relic of an ancient massif composed of Archæan rocks, into which are sunk, in the form of complex anticlines and synclines, several rock groups of undetermined ages, which exist at the present day as lofty mountain ranges or as high plateaux, enclosing the western portion of the Indo-African basin in which the Karroo deposits were laid down.

Note.—A Graptolite, *Diplograptus pristis*, is stated to have been found in the slates of De Kaap, but this discovery has not been confirmed. (Trans. Geol. Soc. South Africa, 1896, vol. i, p. 52.)

V.—Some Trias Sections in South Staffordshire.

By Beeby Thompson, F.C.S., F.G.S.

An occasional visit to a village on the western border of South Staffordshire has given me the opportunity of studying the Triassic deposits around there. Possibly the various sections I have visited are well known to local geologists, although, so far, I have not come across any description of them. One section in particular, I think, must have been overlooked, and this it is now proposed to

describe by way of an introduction to the more important remarks which follow from the pen of Dr. A. Smith Woodward.

A little over a mile to the south-east of Brewood, and a similar distance south-westward of Four Ashes Station on the Wolverhampton to Stafford line of railway, is a small section in the Keuper Sandstones and Marls. The opening is actually very near to Somerford Hall, but at the present time it is known as Chillington Brickyard.

When I first visited this section it was a stone quarry only; at the present time (1901), after having been idle for twelve years, it is being worked for brickmaking only. The possibility of this double use will be evident on reference to the description below.

Section at Chillington Brickyard (taken in 1887).

	ft.	in.
1. Soil with pebbles	1	6
2. Red marl	5	0
3. Soft green marl	1	0
4. Red marl	7	0
5. Hard green marl	0	1
6. Hard red marl	1	0
7. Green sandstone with footprints	0	6
8. Red sandstone with footprints	2	6
9. Green sandstone with footprints	0	6
10. "Best red" sandstone with footprints	7	0

Various layers of the beds 7 to 10 yielded large footprints of *Cheirotherium*. The casts of the impressions made are about ·25 m. and ·15 m. in length and breadth respectively, and the toes raised as much as 20 mm., indicating a comparatively large and heavy animal. Certain other layers were completely covered with casts of impressions of various kinds—worm tracks, worm castings, and small three-toed footprints. Of the five-toed footprints particularly referred to in Dr. Woodward's Notes, the examples I procured on one occasion were the only ones I ever saw at this quarry, although I have visited it four or five times.

No pseudomorphs of salt were discovered, but small flattish crystals of calcium sulphate occurred in some of the green stone (the workmen said pieces like glass), and this, in conjunction with numerous footprints, good ripple-marked and probably rain-pitted slabs at various horizons, suggests deposition of the material in a shallow lake with a fluctuating water-level.

Naturally the stone splits most easily where the footprints occur, the new sediment having been laid down upon a more or less consolidated older one.

It would appear that the Chillington section shows the junction of the Waterstones division of the Upper Keuper with the Red Marls of the same. There is no obvious unconformity, the conspicuous thin, green bands of both divisions being practically parallel.

At Great Chatwell, a few miles to the south-east of Newport (Salop), I found a very much coarser sandstone yielding footprints.

A large slab of stone, about 8 feet by 3 feet, placed beside a stile leading into the old disused quarry, had on it a number of small footprints. The two sections, Chillington and Chatwell, are about seven miles apart.

VI.—Notes on Footprints from the Keuper of South Staffordshire.

By A. Smith Woodward, LL.D., F.R.S., F.G.S.

THE footprints from the fissile Keuper sandstones of Chillington comprise, in addition to the ordinary Cheirotherian impressions, two interesting series. A number of fragments of rock covered with worm tracks and castings, show several imperfectly preserved footprints of a small five-toed animal, with posterior limbs of much greater size than the anterior; and three portions of comparatively smooth slabs afford evidence of a larger animal, probably of the same genus, of which the impressions of the feet are preserved with remarkable distinctness. There are also singular reticulated markings upon the surface of another small slab from the same beds, which may be interpreted as the impression of reptilian (?or labyrinthodont) skin. (See Fig. 2, p. 217.)

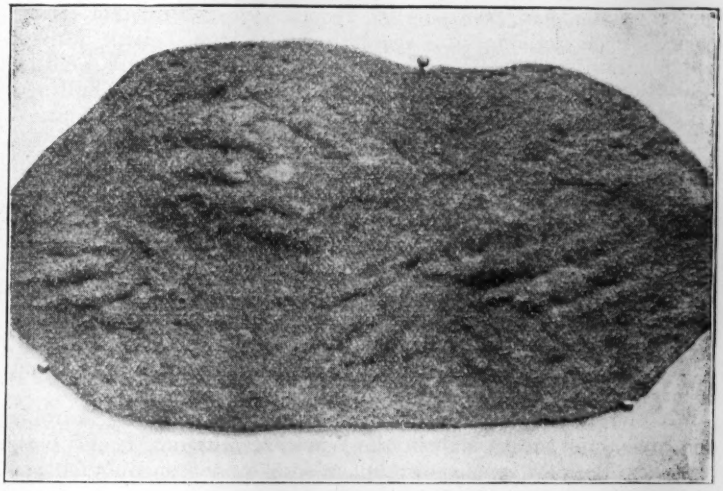

Fig. 1.—Footprints of *Rhynchosaurus* from the Keuper of South Staffordshire.

Of the specimens, the most noteworthy are the series of large five-toed footprints, and these admit of tolerably complete description. Like all the others, they are presented in the form of relief-counterparts of the original impressions. The largest slab (No. I), measuring 0·18 m. by 0·09 m., shows two prints both of the hind- and fore-foot (left side), following in natural succession; a smaller slab (No. II) exhibits one impression of each foot, partly obscured by a film

of matrix; and a third fragment (No. III) shows an imperfect hinder footprint.

In No. I (Fig. 1) the total length of the fore-foot is 0·04 m., and the maximum breadth 0·025 m. As in the hind-foot, the terminal phalanges are very distinctly shown to have the form of sharp claws, and the fifth digit is slightly opposed to the remainder. The joints of digits I to III are well seen, and comprise respectively 2, 3, and 4 phalanges: but Nos. IV and V are unfortunately indistinct. The hind-foot is relatively more elongated than the fore-foot, and measures approximately 0·07 m. in length by 0·038 m. in maximum breadth. The first four toes successively increase in size outwards, but the fifth is very small—perhaps, indeed, the smallest. The number of phalanges is 2, 3, and 4 in digits I to III respectively; and specimen No. II shows clearly that there are 5 in digit IV. The 'palm' of the foot, so to speak, is of considerable length, and in the hind-foot much narrowed posteriorly.

Less distinct footprints of this character have already been ascribed by Sir Richard Owen to *Rhynchosaurus*,[1] and later writers have adopted this interpretation when referring to other similar specimens.[2] It was not until 1887, however, that it became possible to institute a careful comparison of the marks with the actual feet of the genus just mentioned. In that year Professor Huxley described[3] a skeleton of *Rhynchosaurus* in the British Museum, which comprises the broken remains of both fore- and hind-feet, agreeing precisely in relative proportions with the Chillington footprints, and almost identical with these in absolute size. So far as can be determined in the fossil, the number of phalanges in the respective digits is quite lacertilian, and the small dimensions of the fifth digit in the footprints is also suggestive of the latter conforming to the same type. Moreover, *Rhynchosaurus* must have been an animal of sprawling gait, such as would leave the footprints first described by Murchison and Strickland (loc. cit.); and the present specimens, though not in long series, are sufficient to show that a similar form of animal impressed them. The footprints are thus very distinct in character from those of *Cheirotherium*, in which the feet of the right and left sides are seen to have trodden successively almost in a single straight line.

The impression of a web between the toes, noted by Murchison and Strickland in the slab in the Warwick Museum, is not clearly shown in the new specimens; but in some of the smaller footprints appearances are suggestive of its original presence.

[1] R. Owen, "Description of an Extinct Lacertian Reptile, *Rhynchosaurus articeps*, Owen": Trans. Cambridge Phil. Soc., vol. vii (1842), p. 355. Sir Richard Owen refers to the specimens described by O. Ward—"On Footprints and Ripple Marks of the New Red Sandstone of Grinshill Hill, Shropshire," Brit. Assoc. Rep., 1839, Trans. Sect., p. 75; also by Murchison and Strickland, Trans. Geol. Soc. [2], vol. v, p. 339, pl. xxviii, fig. 1, from the Keuper of Shrewley, Warwickshire.

[2] E.g., R. Harkness, "Footprints from Bunter Sandstone, Weston Point, near Runcorn, Cheshire": Ann. Mag. Nat. Hist. [2], vol. vi (1850), pp. 207, 441.

[3] T. H. Huxley: Quart. Journ. Geol. Soc., vol. xliii (1887), pp. 689–692, pl. xxvii.

The slab No. IV (Fig. 2), with impressions apparently of skin, is about six inches square, and the reticulated markings extend over two ill-defined but separate areas. One of these patches is convex and very suggestive of being a portion of the counterpart of a footprint, but there are no marked boundaries. The small polygonal raised areas enclosed by the reticulate markings vary in size in different parts from 0·0015 m. in diameter to 0·004 m. At one side of the slab is an indistinct portion of a small footprint resembling *Rhynchosaurus*.

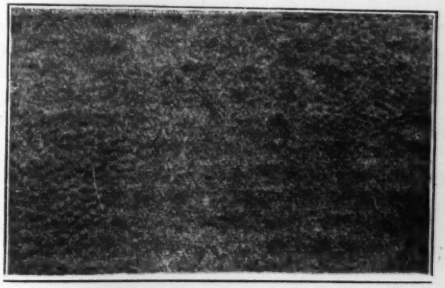

Fig. 2.—Skin impression: footprint of *Cheirotherium* (?).

On comparing this fossil with known specimens, its resemblance to the skin-impression in a Cheirotherian footprint described by Professor Williamson [1] is seen to be very striking. There is also a sun-cracked slab in the British Museum (No. R. 295) from the Trias of Lymm, Cheshire, upon which a number of small Rhynchocephalian footprints are associated with scattered indistinct reticulate markings and enclosed raised areas of a somewhat similar character.

Footprints and impressions are under all circumstances most unsatisfactory fossils to interpret, but it now seems quite certain that Sir Richard Owen's determination of those of *Rhynchosaurus* is correct. It may be convenient to add, in conclusion, that an elaborate synopsis of all that is known regarding such fossils, with full references, was published by Dr. T. C. Winkler in 1886.[2] Later valuable contributions to the same subject have been made by Herr Pabst [3] and Mr. Beasley.[4]

[1] W. C. Williamson, "On a Cheirotherian Footprint from the Base of the Keuper Sandstone of Daresbury, Cheshire": Quart. Journ. Geol. Soc., vol. xxiii (1867), pp. 56–7, pl. iii.

[2] T. C. Winkler, "Histoire de l'Ichnologie": Archiv. Mus. Teyler [2], vol. ii, pt. 4 (1886).

[3] W. Pabst, "Thierfährten aus dem Oberrothliegenden von Tambach in Thüringen": Zeitschr. deutsch. geol. Ges., vol. xlviii (1896), pp. 638-643, pl. xiv; and vol. xlix (1897), pp. 701–712, pls. xxv–xxviii.

[4] H. C. Beasley, "An Attempt to classify the Footprints in the New Red Sandstone of this District": Proc. Liverpool Geol. Soc., vol. vii (1896), pp. 391–409, pls. i–iii. "Notes on Examples of Footprints, etc., from the Trias in some Provincial Museums": loc. cit., vol. viii (1898), pp. 233–237, pl. xi.

VII.—The Cambrian Age of the *Dictyonema* Slates of New Canaan and Kentville, Nova Scotia.

By H. M. Ami, M.A., D.Sc., F.G.S., of the Geological Survey of Canada.

In his "Acadian Geology" (1868, 2nd ed., p. 563) Sir William Dawson figures *Dictyonema Websteri* and places it as a Silurian (Upper Silurian) species. In describing the slates from which the type-specimens of this species were obtained he writes:—"Passing from the Cobequid Mountains to the slate hills of the south side of the Bay" (meaning the Bay of Fundy), "in King's County, we find slates not very dissimilar from those of the Cobequids" (which he had described on the previous page, 562), "in the promontory northward of the Gaspereau River. Here the direction both of the bedding and of the slate structure is N.E. and S.W.; but the planes of cleavage dip to the S.E., while the bedding, as indicated by lines of different colour, dips to the N.W. These slates, with the quartzite and coarse limestones, are continued in the hills of New Canaan, where they contain crinoidal joints, fossil shells, corals, and in some beds of fawn-coloured slate beautiful fan-like expansions of the pretty *Dictyonema*, represented in fig. 196; very fine specimens of this fossil were found by the late Dr. Webster of Kentville. It was the habitation of thousands of minute polypes, similar apparently to those of the modern *Sertularia*. The general strike of the rocks in New Canaan is N.E. and S.W., and they extend from that place westward to the Nictaux River. Westward of Nictaux River, as already mentioned in describing the Devonian, the beds of the Upper Silurian, as well as those of the last-mentioned formation, are interrupted by great masses of granite which form the hills along the south side of the Annapolis River, from a place called Paradise to Bridgetown, and with some interruptions nearly as far as the town of Annapolis."

In my "Synopsis of the Geology of Canada,"[1] the following paragraph refers to the Silurian of the region in question as presented and systematized from available information:—"In the County of Annapolis, Nova Scotia, and in the vicinity of Nictaux, Silurian strata occur, including the *Nictaux* iron-ore beds and the *Torbrook* sandstone formation, whilst near Kentville the Kentville formation is seen as well as on Angus Brook in the Gaspereau valley, also at New Canaan with *Dictyonema Websteri*, Dawson." Slates holding *Dictyonema Websteri*, Dawson, are thus known to occur (1) at New Canaan, N.S., the type locality (2) at Kentville, N.S.; and (3) on the north slope of the South Mountain, along the upper portion of the valley of Angus Brook, a small stream entering the Gaspereau River between the village of Gaspereau and the Avon River shore.

Heretofore, the slates which have yielded the specimens of *Dictyonema Websteri* have been invariably referred to the Silurian system, but more recent examination of the type-specimens of

[1] Trans. Roy. Soc. Canada, 1900–1901, ser. II, vol. vi, sect. 4, p. 203.

D. Websteri have revealed remarkable and indubitable resemblance and close affinity of this species with the *Dictyonema flabelliforme*, Eichwald, which finds a synonym in the *D. sociale* of Salter, a characteristic Upper Cambrian form.

In comparing the microscopical characters of the rhabdosome of *D. Websteri* with those of *D. flabelliforme*, Eichwald, especially as they are presented and illustrated in Carl Wiman's classic work,[1] the peculiar rope-like structure of the polypary is clearly discernible, so that there is practically no doubt as to the identity of the two species.

It will therefore now be necessary to refer *D. Websteri* as a synonym of *D. flabelliforme*, Eichwald, and to refer the Kentville formation, not to the Silurian (Upper) system, but to the Cambrian. In fact, the slates of the Kentville formation of Kings and Annapolis Counties in Nova Scotia are equivalent in age or are taxonomically similar to the slates of Barachois and associated localities in the Nura Series of Cape Breton, as well as to the *Dictyonema* slates of Navy Island, near St. John City, and the slates of Eel River, near Benton in New Brunswick, all of which are referable to the Upper Cambrian.

The first *rapprochement* made by me between *Dictyonema flabelliforme* and *D. Websteri* took place some two years ago, when the specimens of *Dictyonema* obtained by Professor L. W. Bailey near Benton, along the Eel River in York Co., N.B., were compared with the specimens of *D. Websteri* at present in the collections of the Geological Survey Department, and they were found to be so closely related as not to be practically separable. From specimens of *D. flabelliforme* obtained on Navy Island, kindly loaned to me for study and reference by Professor Bailey of the University of New Brunswick, it was readily seen that the Benton specimens were identical and therefore of Upper Cambrian age.

In order to ascertain definitely whether *D. Websteri*, Dawson, from New Canaan, was identical with *D. flabelliforme*, the type-specimens of the former, which formed part of the Dawson collections in the Peter Redpath Museum of McGill University, were kindly loaned to the writer by Professor F. D. Adams. These are preserved on two slabs of more or less hardened red shale or slate, and scattered over the surface of the slates in a rather poor state of preservation, except in one case from which very probably the illustration (fig. 196) on p. 563 of the "Acadian Geology" was prepared.

The writer is satisfied that the upper beds of the Cambrian are thus represented in that portion of Nova Scotia by the *Dictyonema flabelliforme* beds at Kentville, New Canaan, and the Gaspereau Valley, south side.

We thus find that the zone or horizon of *Dictyonema flabelliforme*, Eichwald, occurs at the following localities in Canada, which may consequently be referred to the Upper or Neo-Cambrian :—

[1] See "Ueber die Graptoliten": Bull. Geol. Inst. Upsala, p. 55, pl. x, figs. 13, 14. Also Eichwald, "*Gorgonia flabelliformis*": Sil. Schicht. Syst. in Esthland, 1840, p. 207.

(1) Matanne, Quebec, south shore of St. Lawrence River.
(2) Cape Rosier, Gaspé, Quebec, near Lighthouse.
(3) Barachois, Cape Breton, Nova Scotia.
(4) Navy Island, near St. John, New Brunswick.
(5) Shales near Benton, York County, above Fredericton, New Brunswick.
(6) New Canaan, Annapolis County, Nova Scotia.
(7) Kentville, Annapolis County, Nova Scotia.
(8) Angus Brook, Gaspereau Valley, Kings County, Nova Scotia.

VIII.—A List of the 'Type,' Figured, and Described Fossils in the Norwich Castle Museum.

By Frank Leney, Assistant-Curator of Norwich Museum.

(*Concluded from p.* 171.)

Elephas meridionalis, Nesti. Portion of right lower m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 11, 11*a*, and "Pal. Memoirs" (1868), vol. i, p. 446; vol. ii, p. 136. Leith Adams, ibid., p. 196. Forest Bed (?): Hasbro' Oyster Bed. S. Woodward Coll. 5 [1771].

—— Portion of right lower molar. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 8, 8*a*, and "Pal. Memoirs" (1868), vol. i, p. 445; vol. ii, p. 136. Leith Adams, ibid., p. 192. Forest Bed: Norfolk coast. Old Coll. 18 [1770].

—— Right lower m. 3. Leith Adams, ibid., p. 196. Forest Bed: Bacton. Gurney Coll. 12 [1775].

—— Left lower m. 3. Leith Adams, ibid., p. 197. Forest Bed (?): Bacton. Gurney Coll. 23, 24 [1692, 1704].

—— Left lower m. 3. Leith Adams, ibid., p. 197. Forest Bed: Mundesley cliffs. Gunn Coll. 222 [1712].

—— Portion of left lower m. 3. "Memorials of John Gunn" (1891), p. 68. Norwich Crag: Horstead, Norwich. Gunn Coll. 224 [1573].

—— Left lower m. 3. Leith Adams, ibid., p. 198. Dredged off Norfolk coast. Gunn Coll. 329 [1735].

—— Left lower m. 3. Leith Adams, ibid., p. 197. Forest Bed: Mundesley. Gunn Coll. 317 [1759].

—— Portion of right lower molar. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 9, 9*a*, and "Pal. Memoirs" (1868), vol. i, p. 446; vol. ii, p. 136. Leith Adams, ibid., p. 193. Forest Bed (?): Norfolk coast. S. Woodward Coll. 4 [1783].

—— Right lower molar. "Memorials of John Gunn" (1891), p. 69. Norwich Crag: Horstead, Norwich. Gunn Coll. 305 [1581].

—— Left lower molar. "Memorials of John Gunn" (1891), p. 69. Norwich Crag: Coltishall, Norwich. Gunn Coll. 333 [1576].

—— Portion of lower m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 12, 12*a*, and "Pal. Memoirs" (1868), vol. i, p. 446; vol. ii, p. 136. Leith Adams, ibid., p. 193. Forest Bed: Mundesley. Old Coll. 3 [1778].

Elephas meridionalis, Nesti. Portion of lower molar. Leith Adams, ibid., p. 198. "Memorials of John Gunn" (1891), pl. i (Probos.), pp. 8, 71, fig. E. Forest Bed (?): Hasbro' Oyster Bed. Gunn Coll. 221 [1762].

—— Portion of molar. "Memorials of John Gunn" (1891), p. 69. Norwich Crag: Horstead, Norwich. Gunn Coll. 331 [1583].

—— Left half of pelvis. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 143. Forest Bed: Mundesley cliffs. Gunn Coll. 226 [1611].

—— Left half of pelvis. Falconer, "Pal. Memoirs" (1868), vol. ii, pp. 141–143. Leith Adams, ibid., pp. 150, 151. "Memorials of John Gunn" (1891), pp. 73, 74. Forest Bed: Mundesley. Gunn Coll. 225 [1615].

—— Portion of scapula. Leith Adams, ibid., p. 213, pl. xviii, fig. 3. Dredged off Yarmouth. Gunn Coll. 275 [1618].

—— Left humerus. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 143. Leith Adams, ibid., p. 215, pl. xvi, fig. 2. "Memorials of John Gunn" (1891), p. 73. Forest Bed: Mundesley. Gunn Coll. 200 [1620].

—— Left humerus. Owen, "Brit. Foss. Mammals" (1846), p. 251 (*E. primigenius*). Falconer, "Pal. Memoirs" (1868), vol. ii, p. 143. "Memorials of John Gunn" (1891), pp. 70, 73. Forest Bed: Bacton. Gurney Coll. [1622].

—— Distal end of humerus. Leith Adams, ibid., p. 215, pl. xvi, fig. 3 (Forest Bed *errore*). [? Norwich Crag]: Rockland, Norwich. Mr. J. Hobrough [1619].

—— Radius. Leith Adams, ibid., p. 217. "Memorials of John Gunn" (1891), pp. 74, 75. Forest Bed: Mundesley. Colman Coll. [1621].

—— Right femur. Leith Adams, ibid., pp. 164, 222. "Memorials of John Gunn" (1891), p. 74. Forest Bed: Mundesley. Colman Coll. [1599].

—— Shaft of right femur. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 144. Leith Adams, ibid., p. 224 (No. 288 *errore*). "Memorials of John Gunn" (1891), p. 49. Forest Bed: Walcot, near Bacton. Gunn Coll. 228 [1601].

—— Shaft of femur. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 144. Forest Bed: Norfolk coast. Gunn Coll. 230 [1592].

—— Head of femur. Leith Adams, ibid., p. 224. Forest Bed: Mundesley. Gunn Coll. 237 [1613].

—— Distal end of femur. Leith Adams, ibid., p. 224, pl. xxii, fig. 5 [No. 236 *errore*]. Forest Bed: Bacton. Gunn Coll. 23 [1596].

—— Distal end of femur. Leith Adams, ibid., p. 223. Forest Bed: Palling. Colman Coll. [1606].

—— Left tibia. Leith Adams, ibid., p. 225. Forest Bed: Bacton. Gunn Coll. 241, 242 [1588, 1591].

Elephas meridionalis, Nesti. Fibula. Leith Adams, ibid., p. 226. Dredged off Yarmouth. Gunn Coll. 256 [1953].
—— Distal and proximal ends of fibula. Leith Adams, ibid., p. 226. Forest Bed: Bacton. Gunn Coll. 240 [1607].
—— Distal end of tibia. Leith Adams, ibid., p. 225. Forest Bed: Norfolk coast. Gunn Coll. 243, 247 [1623, 1635].
—— Cuneiforme. Leith Adams, ibid., p. 219. Forest Bed: Norfolk coast. Gunn Coll. 156, 159 [1667, 1671].
—— Internal cuneiforme. Leith Adams, ibid., p. 228, pl. xxi, fig. 2. Forest Bed: Norfolk coast. Gunn Coll. 188 [1954].
—— Unciforme. Leith Adams, ibid., p. 220. Forest Bed: Norfolk coast. Gunn Coll. 172 [1672].
—— Scaphoid. Leith Adams, ibid., p. 159. Forest Bed: Norfolk coast. Gunn Coll. 150 [1660].
—— Lunare. Leith Adams, ibid., p. 159. Forest Bed: Mundesley. Gunn Coll. 151 [1663].
—— Magnum. Leith Adams, ibid., p. 220. Forest Bed (?): Norfolk coast. Gunn Coll. 164 [1658].
—— Trapezoidale. Leith Adams, ibid., p. 220. Dredged off Yarmouth. Gunn Coll. 160 [1661].
—— Metatarsus 3. Leith Adams, ibid., p. 229. Forest Bed: Mundesley. Fitch Coll. [1648].
—— Metatarsus 5. Leith Adams, ibid., p. 329. Forest Bed: Norfolk coast. Gunn Coll. 195 [1645].
—— vide *E. antiquus*, Falc. [1788].
—— vide *Mastodon latidens*, S. Woodw. [1567].
Elephas primigenius, Blum. Incisor tooth. Leith Adams, ibid., p. 187. Submarine deposits near Lowestoft. Colman Coll. [1870].
—— Lower jaw. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 174. "Memorials of John Gunn" (1891), pp. 71, 74, 78, pl. iv (Probos.), fig. 3. Dredged off Margate. Kent. Gunn Coll. 360 [1846].
—— 1st dorsal vertebra. Leith Adams, ibid., p. 149, pl. xvii, fig. 7. Dredged off Lowestoft, Suffolk. Colman Coll. [1931].
—— Left scapula. Leith Adams, ibid., p. 213, pl. xxii, fig. 4. Dredged off Yarmouth. Gunn Coll. 271 [1947].
—— Abnormal right femur. Leith Adams, ibid., p. 167. Dredged off Yarmouth. Gunn Coll. 255 [1912].
—— Lunare. Leith Adams, ibid., p. 159. Dredged off Yarmouth. Gunn Coll. 155 [1651].
—— Molar tooth with glacial markings. "Memorials of John Gunn" (1891), pl. ii (Probos.), fig. K. H. B. Woodward, Proc. Geol. Soc., Aug. 1893, vol. xlix, p. 146. "Reconstructed Chalk": Witton, near Bacton. Gunn Coll. 359 [1949].
—— vide *E. meridionalis*, Nesti [1622].
—— Prototype; vide *E. meridionalis*, Nesti [1696].

Elephas primigenius, Blum. Prototype; vide *E. antiquus*, Falc. [1847].

Elephas (*Loxodon*) *priscus*, Goldfuss. Portion of lower jaw with m. 2. Falconer, Quart. Journ. Geol. Soc., vol. xxi (1865), p. 272, and "Pal. Memoirs" (1868), vol. ii, p. 99, pl. vii, figs. 3, 4. Leith Adams, ibid., p. 23 (*E. antiquus*). Forest Bed: Palling beach. Gunn Coll. 307 [1832].

Elephas sp. Portion of lower molar. "Memorials of John Gunn" (1891), pl. i (Probos.), fig. I (*E. giganteus intermedius*, Gunn MS.). Forest Bed (?): Mundesley. Gunn Coll. H. [1765].

—— Incisor tooth. "Memorials of John Gunn" (1891), p. 79, pl. v (Probos.), fig. 3. Forest Bed (?): Norfolk coast. Rose Coll. N. [1793].

Equus caballus-fossilis, Rütimeyer. Left up. m. 1 and 2. E. T. Newton, "Vert. Forest Bed" (1882), pl. vii, figs. 6, 7. Forest Bed: Cromer. Gunn Coll. [423, 424].

Eucladoceros, Falc.; vide *Cervus Sedgwickii*, Falc. [243].

Gazella anglica, E. T. Newton. Horn-core. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 23. Norwich Crag: Horstead, Norwich. Colman Coll. [1000].

Gulo luscus, Linn. Portion of left ramus of lower jaw. E. T. Newton, Geol. Mag. [2], vol. vii (1880), p. 424; "Vert. Forest Bed" (1882), p. 17, pl. vi. figs. 1, 1*a*. Forest Bed: Mundesley. Fitch Coll. [392].

Hippopotamus major, Owen. Right ramus of lower jaw. Owen, "Brit. Foss. Mamm." (1846), pp. 399, 409, figs. 159, 162. Forest Bed: Cromer. Gurney Coll. [394]. *Type.*

—— Tusk. Owen, ibid., p. 410. Forest Bed (?): Cromer beach. Gurney Coll. [414].

Lutra Reevei, E. T. Newton. Germ carnassial tooth. E. T. Newton, Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 446; "Vert. Pliocene Deposits" (1891), p. 13, pl. i, fig. 13. Norwich Crag: Bramerton, Norwich. Reeve Coll. [548]. *Type.*

Machærodus (?). Carnassial tooth. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 6, pl. i, fig. 2. Norwich Crag: Thorpe, Norwich. Fitch Coll. [549].

Mastodon angustidens, Kaup. Portion of lower tusk. Owen, "Brit. Foss. Mamm." (1846), pp. 291, 295, fig. 101. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 43 (*M. arvernensis*, C. & J.). Fluvio-marine Crag: Norwich. Fitch Coll. [1543].

—— Left upper m.m. 3. Owen, "Brit. Foss. Mamm." (1846), p. 284, fig. 100. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 36 (*M. arvernensis*, C. & J.). Fluvio-marine Crag: Postwick, Norwich. Fitch Coll. [1552].

—— Lower m. 2. Owen, "Brit. Foss. Mamm." (1846), p. 281, fig. 99. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 33 (*M. arvernensis*, C. & J.). Fluvio-marine Crag: near Norwich. Fitch Coll. [1547].

Mastodon angustidens, Kaup.; vide *M. latidens*, S. Woodw. [1567].

Mastodon arvernensis, C. & J. Right upper molar. "Memorials of John Gunn" (1891), p. 67, pl. i (Probos.), fig. A. Norwich Crag: Horstead, Norwich. Gunn Coll. G. [1540].

—— vide *M. angustidens*, Kaup. [1543, 1547, 1552].

Mastodon latidens, S. Woodw. Portion of molar tooth. S. Woodward, Mag. Nat. Hist., vol. ix (1836), p. 154, figs. 23*a*, *b*. Owen, "Brit. Foss. Mamm." (1846), p. 289 (*M. angustidens*, C. & J.). Falconer, "Pal. Memoirs" (1868), vol. ii, p. 131 (*Elephas meridionalis*, Nesti). [Norwich Crag]: Bramerton, Norwich. S. Woodward Coll. [1567].

Monodon monoceros, Linn. Portion of tusk. H. B. Woodward, "Geology of Norwich" (1881), p. 96. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 79. Brickearth: Sprowston, Norwich. Mr. G. Bacon [525].

Ovibos moschatus, Zimm. Skull. Boyd Dawkins, Quart. Journ. Geol. Soc., vol. xxxix (1883), p. 575, woodcut. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 22. Forest Bed: Trimmingham. Rev. F. Buxton [487].

Ovis aries, Linn. Metatarsal. "Memorials of John Gunn" (1891), p. 58, pl. ii (Probos.), figs. *a*, *b*. Recent deposit: Happisburgh. Gunn Coll. I [9].

Phoca sp. Right humerus. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 19, pl. ii, fig. 1. Norwich Crag: Bramerton, Norwich. Crowfoot and Dowson Coll. [380].

Rangifer tarandus (Linn.); vide *Cervus tarandus*, Linn. [70].

Rhinoceros etruscus, Falc.; vide *R. tichorinus*, Fischer [460].

Rhinoceros leptorhinus, Owen. Upper molar tooth. Owen, "Brit. Foss. Mamm." (1846), p. 381. Forest Bed: near Cromer. Fitch Coll. [448].

Rhinoceros leptorhinus, Owen; vide *R. megarhinus*, Christol [446].

Rhinoceros megarhinus, Christol. Right upper p.m. 4. Boyd Dawkins, Quart. Journ. Geol. Soc., vol. xxiii (1867), p. 214. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 398 (*R. leptorhinus*, Owen). E. T. Newton, "Vert. Forest Bed" (1882), p. 40, pl. ix, fig. 1. Forest Bed: near Cromer. Gunn Coll. [446].

Rhinoceros tichorhinus, Fischer. Left ramus of lower jaw. Owen, "Brit. Foss. Mamm." (1846), p. 347. Falconer, "Pal. Memoirs" (1868), pp. 347, 355 (*R. etruscus*, Falc.). E. T. Newton, "Vert. Forest Bed" (1882), p. 39, pl. viii, fig. 7. Forest Bed: Cromer. Fitch Coll. [460].

Strongyloceros, Falconer; vide *Cervus verticornis*, Dawk. [305].

Talpa europæa, Linn. Right and left lower jaws. E. T. Newton, "Vert. Forest Bed" (1882), p. 95, pl. xv, figs. 1, 2. Forest Bed: Bacton. Gurney Coll. [523].

Trichechus Huxleyi (?), Lank. Proximal half of right femur. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 18, pl. ii, fig. 3. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [393].

Trogontherium Cuvieri, Cuvier. Right ramus of lower jaw. E. T. Newton, "Vert. Forest Bed" (1882), pl. xi, fig. 9. Forest Bed: Mundesley. Fitch Coll. [381].

—— Left ramus of lower jaw. Owen, Geol. Mag., vol. vi (1869), p. 52, fig. 4. E. T. Newton, "Vert. Forest Bed" (1882), p. 69, pl. xi, fig. 11. Forest Bed: Mundesley. Fitch Coll. [382].

—— Left ramus of lower jaw. E. T. Newton, "Vert. Forest Bed" (1882), p. 69, pl. xi, fig. 7. Forest Bed: Bacton. Gurney Coll. [383].

—— Left femur. Owen, Geol. Mag., vol. vi (1869), p. 49, pl. iii, figs. 1–4. E. T. Newton, "Vert. Forest Bed" (1882), p. 74, pl. xi, fig. 18. Forest Bed: Mundesley. Gunn Coll. [387].

—— Left calcaneum. Owen, Geol. Mag., vol. vi (1869), p. 49, pl. iii, fig. 8. E. T. Newton, "Vert. Forest Bed" (1882), p. 74, pl. xi, fig. 20. Forest Bed: Mundesley. Gunn Coll. [386].

Ursus spelæus, Blum. Left ramus of lower jaw. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 466 (*Ursus* sp.). E. T. Newton, "Vert. Forest Bed" (1882), p. 7, pl. i, fig. 2; pl. iii, fig. 2. Forest Bed: Cromer. Gurney Coll. [375].

—— Portion of left ramus of lower jaw. E. T. Newton, "Vert. Forest Bed" (1882), p. 10, pl. iii, fig. 3. Forest Bed: Norfolk coast. Old Coll. [371].

—— Canine tooth. E. T. Newton, "Vert. Forest Bed" (1882), p. 11, pl. ii, fig. 8. Forest Bed (?): Norfolk coast. Gunn Coll. [378].

—— Distal end of left humerus. E. T. Newton, "Vert. Forest Bed" (1882), p. 14, pl. ii, fig. 4. Forest Bed: Happisburgh. Gunn Coll. 380 [374].

Rodent ? genus. Cheek tooth. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 54, pl. v, fig. 19. Norwich Crag: Bramerton, Norwich. Reeve Coll. [544].

Small Ruminant. Outer incisor tooth. E. T. Newton, "Vert. Pliocene Deposits" (1891), pl. iii, fig. 10. Norwich Crag: Thorpe, Norwich. Fitch Coll. [550].

AVES.

Grus communis, Bechs. Tibiæ and radius. A. Newton, Trans. Norf. and Nor. Nat. Soc., vol. vii (1901), p. 158. Peat [Estuarine Deposit]: King's Lynn. Gunn Coll. [1978].

Uria troile, Linn. Shaft of humerus. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 84, pl. ix, fig. 5. Chillesford Crag: Aldeby, Suffolk. Crowfoot and Dowson Coll. [547].

REPTILIA.

Chelonia harviciensis, S. Woodward. S. Woodward, "Synoptical Table" (1830), p. 44, frontispiece. London Clay: Harwich Harbour. Rev. J. H. Bloom [1517]. *Type.*

Emys lutaria, Schneider. Carapace. E. T. Newton, Geol. Mag. [2], vol. vi (1879), p. 304, pl. viii. H. B. Woodward, Trans. Norf. and Nor. Nat. Soc., vol. iii (1880), p. 36. Clement Reid, "Geology of Cromer" (1882), p. 119. "River Bed": Mundesley. John Gurney, Esq. [160].

Leiodon anceps, Owen. Vertebræ. T. G. Bayfield, Geol. Mag., vol. i (1864), p. 296. Upper Chalk: Lollard's Pit, Norwich. T. G. Bayfield, Esq. [1983].

PISCES.

Gadus morrhua, Linn. Otolith. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 93, pl. x, fig. 5. Norwich Crag: Bramerton, Norwich. Reeve Coll. [546].

Gadus pollachius, Linn. Portion of otolith. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 96, pl. x, fig. 15. Norwich Crag: Bramerton, Norwich. Reeve Coll. [545].

CRUSTACEA.

Pollicipes Angelini, Darwin. Scutum and tergum. C. Darwin, "Fossil Lepadidæ" (Pal. Soc., 1851), p. 56, tab. iii, fig. 7. Upper Chalk: Norwich. Fitch Coll. [2152]. *Types.*

Pollicipes fallax, Darwin. Scutum and tergum. C. Darwin, ibid., p. 75, tab. iv, fig. 8. Upper Chalk: Norwich. Fitch Coll. [2153]. *Types.*

Pollicipes striatus, Darwin. Carina, tergum, and scutum. C. Darwin, ibid., p. 71, tab. iv, fig. 5. Upper Chalk: Norwich. Fitch Coll. [2154]. *Types.*

Scalpellum fossula, Darwin. Associated plates. C. Darwin, ibid., p. 24, tab. i, fig. 4. Upper Chalk: Norwich. Fitch Coll. [2136]. *Type.*

Scalpellum maximum, J. Sow., var. *typicum*, Darwin. Scutum. C. Darwin, ibid., p. 28, tab. ii, fig. 8. Upper Chalk: Norwich. Fitch Coll. [2139].

—— —— Carina. C. Darwin, ibid., p. 28. Upper Chalk: Norwich. Fitch Coll. [2138].

—— —— var. i. Tergum. C. Darwin, ibid., p. 30, tab. ii, fig. 5. Upper Chalk: Norwich. Fitch Coll. [2141].

—— —— var. ii. Scutum. C. Darwin, ibid., p. 29, tab. ii, fig. 9. Upper Chalk: Norwich. Fitch Coll. [2147].

—— —— var. ii. Tergum. C. Darwin, ibid., p. 30, tab. ii, fig. 6. Upper Chalk: Norwich. Fitch Coll. [2145].

—— —— var. iii. Tergum. C. Darwin, ibid., p. 31, tab. ii, fig. 7. Upper Chalk: Norwich. Fitch Coll. [2142].

ANNELIDA.

Vermicularia (?). S. Woodward, "Geology of Norfolk" (1833), p. 49, tab. vi, fig. 18. Upper Chalk: Norwich. S. Woodward Coll. [2230].

Vermilia macropus, J. Sow. S. Woodward, ibid., tab. v, fig. 18. Upper Chalk: Norwich. S. Woodward Coll. [3330].

ECHINODERMATA.

Ananchytes Bayfieldi, S. P. Woodward MS. H. B. Woodward, "Geology of Norwich" (1881), p. 27. Flint Gravel: Norwich. S. Woodward Coll. [2232].

Asterias lunatus, S. Woodward. S. Woodward, "Geology of Norfolk" (1833), tab. v, fig. 1. "Hard Chalk": West Norfolk. S. Woodward Coll. [3307]. *Type.*

Ophiura Fitchii, Forbes MS. H. B. Woodward, "Geology of Norwich" (1881), p. 27. Flint Gravel: Norwich. Fitch Coll. [2294].

Spatangus excentricus, Rosé. S. Woodward, "Geology of Norfolk" (1833). p. 57, pl. i, fig. 5. Flint Gravel: near Norwich. S. Woodward Coll. [3308].

GASTEROPODA.

Buccinum Dalei, J. Sow. S. V. Wood, "Crag Moll.," Suppl. (1872), p. 16. Fluvio-marine Crag: Postwick, Norwich. Reeve Coll. [829].

Cassis avellana, Brong. S. Woodward, "Geology of Norfolk" (1833), tab. vi, fig. 22. Upper Chalk: Norwich. S. Woodward Coll. [2107].

Cerithium derivatum, S. V. Wood. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 39, woodcut. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [754]. *Type.*

Cerithium Greenii (?), Adams. S. V. Wood, ibid., p. 23, tab. iv, fig. 16 (*Sandbergeria Reevei*, S. V. Wood MS.). Chillesford Beds: Bramerton, Norwich. Reeve Coll. [755].

Cerithium unicarinatum, S. Woodw. S. Woodward, "Geology of Norfolk" (1833), tab. vi, fig. 21. Upper Chalk: Harford Bridge, Norwich. S. Woodward Coll. [2106]. *Type.*

Chemnitzia internodula (?), S. V. Wood, var. *ligata*, S. V. Wood. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 24, tab. ii, fig. 11. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [570].

Hydrobia obtusa, Sandb. S. V. Wood, ibid., p. 30, tab. iv, fig. 7. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [756].

Limnæa auricularia, Linn. S. V. Wood, ibid., p. 36, tab. iv, fig. 3*a*. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [757].

Limnæa palustris, Müll. S. V. Wood, ibid., p. 37, tab. iv, fig. 2. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [584*a*].

Margarita argentata (?), Gould. S. V. Wood, "Crag Moll.," Suppl. (1872), p. 84, tab. v, fig. 12. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [896].

Odostomia (?) *derivata*, S. V. Wood. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 40, woodcut. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [758].

Odostomia Reevei, S. V. Wood. S. V. Wood, "Crag Moll.," 3rd Suppl. (1882), p. 9, tab. i, fig. 12. Fluvio-marine Crag: Bramerton, Norfolk. Reeve Coll. [762]. *Type.*

Odostomia sp. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 40. Fluvio-marine Crag: Bramerton, Norfolk. Reeve Coll. [759].

Paludestrina Reevei, A. S. K. & B. B. W. A. S. Kennard & B. B. Woodward, Proc. Malac. Soc., vol. iii (1899), p. 198, woodcut. Norwich Crag: Blake's Pit, Bramerton. Reeve Coll. [767]. *Type.*

Pupa edentula, Drap. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 37, tab. iv, fig. 6. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [760].

Purpura lapillus, Linn. S. V. Wood, ibid., p. 5, tab. i, fig. 13. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [616*a*].

Rissoa proxima, Alder. S. V. Wood, ibid., p. 40. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [761].

Sandbergeria Reevei, S. V. Wood MS.; vide *Cerithium Greenii*, Adams [755].

Scalaria Trevelyana, Leach. S. V. Wood, "Crag Moll.," Suppl. (1872), p. 58, tab. iv, fig. 6. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [905].

Trophon antiquus, Linn., var. ***carinatus contrarius***, S. V. Wood. S. V. Wood, "Crag Moll.," Suppl. (1872), p. 19, tab. i, fig. 10*a*. Fluvio-marine Crag: Bramerton (?), Norwich. Captain Alexander [849].

LAMELLIBRANCHIATA.

Cultellus pellucidus (?), Penn. S. V. Wood, "Crag Moll.," Suppl. (1874), p. 148, tab. x, fig. 14. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [928].

Inoceramus latus, Mant. S. Woodward, "Geology of Norfolk" (1833), tab. i, fig. 7. Flint Gravel: Norwich. S. Woodward Coll. [2229].

Lasæa intermedia, S. V. Wood. S. V. Wood, "Crag Moll.," Suppl. (1874), p. 123, tab. x, fig. 22*b*. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [932]. *Type.* [Probably the figured specimen, S. V. W. MS.]

Lucina borealis, Linn. S. V. Wood, ibid., p. 128, tab. ix, fig. 5. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [937].

Lucinopsis undata, Penn. S. V. Wood, ibid., p. 129, tab. ix, fig. 4. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [938].

Ostrea alæformis, S. Woodw. S. Woodward, "Geology of Norfolk" (1883), p. 48, tab. vi, fig. 3. Upper Chalk: Norwich. S. Woodward Coll. [2100]. *Type.*

Ostrea triangularis, S. Woodw. S. Woodward, ibid., tab. vi, **fig. 7**. Upper Chalk: Harford Bridge, Norwich. S. Woodward Coll. [2099]. *Type.*

Pecten princeps, J. Sow., var. ***pseudo-princeps***, S. V. Wood. S. V. Wood, "Crag Moll.," Suppl. (1874), p. 103, tab. viii, fig. 9*b*. Fluvio-marine Crag: Bramerton, Norwich. Captain Alexander [873].

Pinna sulcata, S. Woodw. S. Woodward, "Geology of Norfolk" (1833), tab. v, fig. 23. Upper Chalk: St. Giles' Gate, Norwich. S. Woodward Coll. [2111].

Siliquaria parva, Speyer. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 40; 3rd Suppl. (1882), p. 11, tab. i, figs. **16*a*, *b***. Fluvio-marine Crag: Bramerton, Norwich. **Reeve Coll.** [763].

Spondylus Dutempleanus, D'Orb. H. Woods, "Cret. Lamell." (Pal. Soc., 1901), pl. xxiii, figs. 3, 5. Upper Chalk: Norwich. Fitch Coll. [2113, 2114].

BRACHIOPODA.

Crania striata, Rose. S. Woodward, "Geology of Norfolk" (1833), p. 48, tab. vi, fig. 15. Upper Chalk: Harford Bridge, Norwich. S. Woodward Coll. [2231].

Kingena lima (Defr.). Davidson, "Cret. Brachiopoda" (Pal. Soc., 1852), p. 45, pl. iv, figs. 17, 19. Chalk: Letheringsett. Rose Coll. [3219].

—— Davidson, ibid., p. 45, pl. iv, fig. 20. Upper Chalk: Norwich. Fitch Coll. [2060].

Magas pumilus, Sow. Davidson, ibid., p. 24, pl. ii, figs. 7, 8. Chalk: Letheringsett. Rose Coll. [3218].

Rhynchonella limbata (Schl.). Davidson, ibid., p. 80, pl. xii, figs. 1, 2, 3 [fig. 3 not found]. Upper Chalk: Norwich. Fitch Coll. [2065].

Rhynchonella plicatilis, Sow., var. ***octoplicata***, Sow. Davidson, ibid., p. 78, pl. x, figs. 1–11 [= 8 specimens]. Upper Chalk: Norwich. Fitch Coll. [2068].

Rhynchonella plicatilis, Sow., var. ***Woodwardii***, Dav. Davidson, ibid., p. 79, pl. x, figs. 43, 44. Upper Chalk: Norwich. Fitch Coll. [2069].

Terebratula biplicata (Brocchi), var. ***Dutempleana***, D'Orb. Davidson, ibid., p. 57, pl. vi, figs. 1, 2. Red Chalk: Hunstanton. Fitch Coll. [2830].

Terebratula capillata, D'Archiac. Davidson, ibid., p. 46, **pl. v**, fig. 12. Red Chalk: Hunstanton. Fitch Coll. [2833].

Terebratula carnea, Sow., var. ***elongata***, Sow. Davidson, ibid., p. 70, pl. viii, fig. 3. Upper Chalk: Norwich. Fitch Coll. [2072].

Terebratula obesa, Sow. Davidson, ibid., p. 54, **pl. v**, figs, **13, 14**. Upper Chalk: Norwich. Fitch Coll. [2074, 2075].

Terebratulina gracilis (Schl.). Davidson, ibid., p. 40, pl. ii, **fig. 14**. Upper Chalk: Norwich. Fitch Coll. [2081].

Terebratulina striata (Wahl.). Davidson, ibid., p. 38, pl. ii, fig. 18. Upper Chalk: Norwich. Fitch Coll. [2080].

Trigonosemus elegans, Koenig. Davidson, ibid., p. 30, pl. iv, figs. 1, 2. Upper Chalk: Norwich. Fitch Coll. [2079].

POLYZOA.

Flustra foliacea (?), S. Woodw. S. Woodward, "Geology of Norfolk" (1883), tab. i, fig. 4. Flint Gravel: Norwich. S. Woodward [2228]. *Type.*

SPONGIDA.

Ventriculites infundibuliformis, S. Woodw. S. Woodward, "Geology of Norfolk" (1833), tab. iv, fig. 21. Upper Chalk: Norwich. S. Woodward Coll. [2222]. *Type.*

The following specimens have not been found:—

Mastodon angustidens, Kaup. Molar tooth, figured by Owen, "Brit. Foss. Mamm." (1846), p. 283, fig. 98.

Rhynchonella limbata (Schl.), figured by Davidson, "Cret. Brachiopoda" (Pal. Soc., 1852), pl. xii, fig. 3.

Assiminea Grayana (?), Leach, figured by S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), tab. iii, fig. 18.

I am much indebted to Mr. James Reeve, F.G.S., Curator of the Norwich Castle Museum, without whose long and intimate knowledge of the collection this list could not have been satisfactorily completed. My thanks are also due to Dr. A. Smith Woodward, F.R.S., of the British Museum (Nat. Hist.), for his kind encouragement.

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Proc. Geol. Soc.—Proceedings of the Geological Society. London.

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COLLECTIONS.

Colman Collection.—A collection of mammalian remains from the "Forest Bed" deposits of Norfolk and Suffolk, formed by the late J. J. Colman, Esq., M.P. Presented by Russell J. Colman, Esq., 1898.

Crowfoot and Dowson Collection.—A small collection representative of the fauna of the Norwich Crag at Aldeby, Suffolk. A list is published in the Proceedings of the Norwich Geological Society, vol. i (1878–9), pp. 24, 81. Presented by Messrs. W. M. Crowfoot, M.B., and E. T. Dowson, 1868.

Fitch Collection.—A general collection of fossils, mostly of local origin, including a very fine series from the Chalk of Norwich, and mammalian remains from the "Forest Bed." Presented by the late Robert Fitch, Esq., F.S.A., F.G.S., 1893.

Gunn Collection.—A large series of mammalian remains from the "Forest Bed" deposits of the Norfolk coast. For a history and description of this collection see "Memorials of John Gunn" (1891). Presented by the Rev. John Gunn, M.A., F.G.S., 1868.

Gurney Collection.—This collection was formed early in the last century by Miss Anna Gurney, of Northrepps Cottage, Cromer, and contains some rare examples of mammalian remains from the "Forest Bed" of Cromer. Presented 1845.

Johnson Collection.—A collection formed by Randall Johnson, Esq., of Waxham. It includes some perfect limb-bones of Elephants from the "Forest Bed." It was acquired by J. J. Colman, Esq., and incorporated in his collection. (See Trans. Norf. and Nor. Nat. Soc., vol. ii, 1877, p. 279.)

Reeve Collection.—A representative series of the molluscan fauna of the Norwich Crag at Bramerton, near Norwich. This collection, the result of thirty years' work, is referred to in nearly every work on the Crag deposits, and a list is published in the Proceedings of the Norwich Geological Society, vol. i (1879–81), pp. 69, 110. Collected and presented by James Reeve, Esq., F.G.S., Curator of Norwich Museum.

S. Woodward Collection.—A general collection formed by Samuel Woodward, Esq., author of "Geology of Norfolk" (1833), etc. The collection of fossils does not appear to have been received in its entirety, as it is impossible to trace more than a few of the specimens figured in the above work. Purchased by subscription, 1839. (See Trans. Norf. and Nor. Nat. Soc., vol. ii, 1879, p. 588.)

The *Norwich Museum* was founded in 1824, and taken over by the Corporation of the city in 1894. For an account of its origin and progress see Guide Book by Thomas Southwell, Esq., F.Z.S., Norwich, 1896.

REVIEWS.

I.—The Scenery of England and the Causes to which it is due. By the Right Hon. Lord Avebury (Sir John Lubbock, Bart.), F.R.S., D.C.L., LL.D., F.G.S., etc. Royal 8vo; pp. 534, with 197 illustrations. (London: Macmillan & Co., Ltd., 1902. Price 15*s.* nett.)

(PLATES XIII and XIV.)

THE name of Lubbock is one to conjure with, and has for so many years arrested public attention, and become "familiar in their mouths as household words," that it is no easy matter to abandon the memory of it, or to recognize our esteemed and valued friend under his new guise, however high be the dignity which the title confers.

In his capacity as a popular writer it may be truly said of the author *Nihil quod tetigit sed ornavit*, and certainly the field of his discourses has been wide indeed. From 1865, when he wrote on Prehistoric Times; Primitive Man; and the Origin of Civilization; to the Use and the Pleasures of Life, and the Beauties of Nature; of Flowers, Fruit, and Leaves; of British Wild Flowers; of Insects; Ants, Bees, and Wasps; and many other "Chapters in Popular Natural History"; we pass on to the "Scenery of Switzerland," and now to that of England itself.

In the writings of the early fathers we find the surface of the primitive earth described as, originally, perfectly smooth, but after the wickedness of mankind had brought upon it the Noachian Deluge the fountains of the great deep were broken up, and the ruptured portions of the heretofore united crust floated about on the liberated waters and became continents and islands, according to their sizes, whilst other pieces of the crust, being forced upon their beam-ends, became converted into mountain-chains. This is a simple, if not very accurate explanation of Nature; but the careful study of geology in the past hundred years has led to our being shown a more excellent way of interpreting the groundwork of Nature. We find that many and varied forces have contributed to bring about the present configuration of our earth's surface, and although the main land-masses and the deeper oceanic depressions were doubtless sketched out in Palæozoic times, yet the minor details resulting from later sedimentary deposits in shallower seas, the elevation of mountain-chains, the carving and shaping of land-surfaces, and the production of plateaux and steppes, of hills and valleys, all in fact which constitutes our scenery, is but a thing of yesterday, geologically speaking, although the expression "old as the hills" still remains perfectly true when comparing Nature's smallest operations with the pigmy events and periods in man's ephemeral calendar of existence.

When one looks at the long array of geological textbooks upon one's bookshelf it seems at first difficult to accept the justice of Lord Avebury's indictment that our geological literature is very much scattered, that it has to be sought for in innumerable memoirs,

Curve on the Wye near Chepstow.

[From "The Scenery of England and Wales," by Lord Avebury (p. 296) : Macmillan & Co.]

Lower Fall, Aysgarth, Wensleydale, Yorkshire.

[From "The Scenery of England and Wales," by Lord Avebury (p. 335): Macmillan & Co.]

or in the publications of learned and often of local societies; but there is, after all, much truth in this aspect, and more still in the fact that very few of our geological writers possess the happy method of placing the dry bones of our science in an attractive manner before the ordinary reader, or can show that there is a romance and poetry in the geological aspect of "hill and dale and wooded grove," which may even move the commonplace reader, or the ordinary man in the omnibus, to enquire what are the causes which have brought about the present scenery of England.

In the earlier days of our science, geological observers dealt largely in cataclysmic and paroxysmal action, and firmly believed in the *sea* as the great denuding agent, assisted by the frequent and often sudden elevation or subsidence of the land by volcanic or earthquake movements, and that to these agencies the wearing away and carving out of the land were chiefly due.

One is readily impressed by noise and commotion; thus the loud striking of the clock affects one's nerves more forcibly than the gentle yet constant oscillation of the pendulum, doing its ceaseless yet silent work. So, too, in Nature the lightning and thunder of the tempest, the eruption of the volcano, the violence of the earthquake, and the roar of the storm-swept sea, vividly impress our imagination; but it needs a careful observer to appreciate the work of her quieter but ceaseless agents, the sun, the atmosphere, frost, snow, and ice, and her constant carriers, rain and rivers.

Lord Avebury cites Mackintosh's "Scenery of England and Wales" "as an illustration of a work written under the belief that the configuration, and consequently the scenery, was mainly due to marine action." "Subsequent researches have led to, I think, a general agreement that subaerial action has been the predominant partner." Again, "The sea" (writes the author) "can only act along the coast-line; rain is ubiquitous." "Sea-erosion is horizontal and leaves headlands; rain-erosion is vertical and leaves hills; along the coast the harder rocks stand out, inland they stand up" (p. 136).

It was because of their apparent insignificance that rain and rivers, frost, snow, and ice were at first neglected by geologists; now we see the vast importance of these agents, whilst still crediting the sea, the volcano, and earthquake with their due. In the pages of this Magazine may be found numerous articles by Mr. Poulett Scrope (1866), Sir A. Geikie, Mr. W. Whitaker (1867), Colonel Greenwood, and many other writers, showing how fully the effect of subaerial denudation has been understood and advocated by all advanced geologists long since.

But to return to "The Scenery of England." The first two chapters are devoted to sedimentary and other geology, and give the reader an epitome of the igneous and sedimentary rocks from the Archæan to the Quaternary, the latest having by far the larger share of space given to them, for, although the youngest and most superficial deposits, they affect the present surface of the ground, and often mask the older rocks beneath Drift and Boulder-clay, or

beds of gravel and sand, erratics or peat. The chapters which follow deal with the general Configuration of our Island; the Coast; the Origin of Mountains; Volcanoes; the History of Rivers, their Courses; Lakes; the Influence of Rocks on Scenery; Downs, Wolds, Fens, Moors, and Commons; Law, Custom, and Scenery; Sites of Towns; and Conclusion.

The full enjoyment of our scenery can only be realized by those who, while admiring its picturesqueness, recognize that the wonderful story of its origin and development is still more absorbing. It is no longer difficult to acquire an elementary knowledge of the mode of deposition of the sedimentary rocks, of their position in the geological series, and of the fossils which characterize them.

To those who have not already studied the subject, the first chapters in Lord Avebury's book will provide a most useful introduction, and, like the draught and pills of the apothecary, the book may be accompanied by a dose of Woodward's Table of British Strata and Geikie's Geologically Coloured Map of England and Wales, each hanging from its appropriate nail on the library wall, ready for reference. As a matter of necessity in such a book, mountains, hills, rivers, and lakes occupy an important place, and of necessity fill a large space (eight chapters and nearly 250 pages) in the scenery of England.

And here, parenthetically, we would venture to ask his Lordship, since he includes Wales in his book, why does he not call it the "Scenery of England and Wales"? It must be on the principle that the greater includes the less; nevertheless, the Principality, with a population of 1,698,161 and a Prince of its own, will surely rise up to a man "to know the reason why" Snowdon is spoken of as "our loftiest *English* mountain"! Spirit of Owain Glyndwr du (Owen Glendower), awake! arise! defend thy heritage as of old.

There are few points in the physical geography and scenery of our country which can be explained without a clue from its geological construction. In the peculiar courses followed by some of our rivers, which occasionally take an apparently inexplicable turn at nearly a right angle, the secret may lie in the direction taken by great lines of fracture in the rocks. In general the great lines of uplift and the varying nature of the rocks have exerted most influence. The subject is a complex one, but the history of rivers is fully dealt with by the author in the light of the most recent researches on the subject.

It is, perhaps, unfortunate that figures should ever be used to express the immensity of geological time. There are few readers who can realize the meaning of 100,000,000 years, which the author says must have elapsed since the commencement of life on our planet, or of 200,000 years since the beginning of the Glacial Period, or even of the 50,000 years before our time at which that period may have ended. Geological time is better expressed in terms of the changes which have taken place during its progress. "The top of Snowdon was once the bottom of a valley"; "Our Scotch and Welsh mountains are so low because they are so old,"

as compared with the Alps, Himalayas, and other ranges, which are, indeed, all newer than the London Clay. Phrases such as these convey the idea of geological time better than ciphers.

In the later chapters we seem to be walking by the side of the writer by rivers, lakes, and sea-shore; over downs, fens, moors, and commons. Everything he tells us is full of interest, and he leaves nothing untouched. Geology, scenery, animal life, botany, history, ancient laws and customs, anecdote, poetry, all are there. As to illustration, the book may be considered as a small but very choice photographic album of English scenery. We introduce two only, out of nearly 200 pictures, but they are all so excellent in their several ways that one needs the book itself to realize how good they are.

In his preface the author says: "If the book be half as interesting to read as I have found it to write, I may venture to hope that it may serve as an introduction to this fascinating branch of science." It is not only interest that Lord Avebury introduces into his subject, but enthusiasm. J. A. W.

II.—Geological Survey of Canada. G. M. Dawson, C.M.G., LL.D., F.R.S., Director. Annual Report (New Series), Vol. XI: Reports A, D, F, G, J, L, M, R, S. Plates and Maps. (Ottawa: S. E. Dawson, 1901.)

BEFORE beginning this notice of the work of the Canadian Geological Survey the writer, as an old friend and former colleague of the late Director, craves permission to record his deep regret at the great loss suffered by the Survey in the death of their chief, a loss which seriously affects alike geological science at large and that of the country which was the field of his labours.

The Summary Report (A) by the late Director need only be briefly touched upon, as it relates, for the most part, to work which has already been passed under review in this Magazine. It concerns, as usual, the explorations and surveys in progress at the time, the publications connected with the museum, and the work carried on there and in the offices attached to it. Perhaps the most interesting observations are those relating to the Klondike Gold District by Messrs. R. G. McConnell and J. Burr Tyrrell. We learn from them that the productive area traversed by the gold-bearing creeks is 1,000 square miles. The gold occurs in the gravel flooring at the bottom of the valleys, and in stream-terraces lining their lower slopes. The gravels rest on an irregular floor of decomposed mica-schist and quartz-schist, underlying which is a quartzose, micaceous, and sericitic schist (the rock of the district), of sedimentary or volcanic origin, highly altered by dynamic agencies. This rock is of early Palæozoic, probably Cambrian age.

The great richness of the Klondike placer ground depends, first, on the presence of a highly gold-bearing rock, and secondly, on the occurrence of a set of conditions peculiarly favourable to the concentration of the precious metal.

Mr. D. B. Dowling's report (F) treats of the geology of the west shore and islands of Lake Winnipeg, the notes prepared by Mr. J. B.

Tyrrell, his predecessor, being used to make the descriptions of the formations more complete. The first part of the report is occupied with a detailed account of the physical geography of the area surveyed. A table is given correlating the formations of Manitoba and Minnesota, and a long list of fossils from the Cambro-Silurian (Ordovician) of Manitoba, including those of the Trenton and Black River of Lake Winnipeg compiled from the "Palæozoic Fossils," vol. iii, of Dr. J. F. Whiteaves.

The next report (G), by Mr. J. Burr Tyrrell, "On the east shore of Lake Winnipeg and adjacent parts of Manitoba and Keewatin," is compiled by Mr. Dowling from Mr. Tyrrell's notes and surveys. It takes the shape of a description of the lake, starting from the northern end and going southward. A carefully prepared topographical and orographical account serves as an introduction; the geological features follow. The rocks are Archæan, the great preponderance of gneisses and granites of the Laurentian being the chief feature; there are also local occurrences of Huronian greenstones and schists. A coloured geological map of the lake on a scale of 8 miles to 1 inch accompanies this report.

Dr. R. W. Ells contributes a report (J) on the geology of the area comprised in the north-west quarter-sheet of the "Eastern Townships" map, or Three Rivers sheet, of the Province of Quebec. The Palæozoic formations observed are the Potsdam, Calciferous, Chazy, Black River, and Trenton to the north of the St. Lawrence River, and the Utica, Hudson River, and an outlier of the Medina in the small area to the south of the St. Lawrence included in the tract of country surveyed. Full lists of the fossils obtained are given, their identification having been entrusted to the competent hands of Dr. H. M. Ami. Some crystalline rocks of the "Grenville Series" also occur, with large areas of anorthosite, red granite, augen-gneiss, and masses of green pyroxenic diabase. The map accompanying this report is drawn to a scale of 4 miles to 1 inch.

Mr. A. P. Low's report (L) contains an account of his exploration of part of the south shore of Hudson Strait, and of Ungava Bay. These distant expeditions are not without their elements of danger and adventure, and the narrative of the voyage in a sealing steamer from Halifax to Hudson Bay *viâ* the Straits of Belle Isle, and the subsequent incidents of the coasting voyage in a small yacht along the shore of Hudson Strait, serve fully to impress this upon the reader. Making their way slowly through pack ice, and with many delays, the voyagers reached Hudson Bay on the 12th July, having left port on the 3rd June. Leaving the steamer in King George Sound they took to their small yacht. The route lay along the coast from the Sound to the head of Ungava Bay. The nature of the country, as far as could be seen from the coast and from some of the streams, is described as high, rocky, and barren, and this description is fully realized in the illustrations (from photographs) which accompany the report.

The long line of coast explored in the limited time at the disposal of the expedition admitted only of a hurried examination each day.

The rocks met with were all found to be of great antiquity, all more or less altered by pressure induced by intrusions of igneous masses, which folded the bedded series and produced foliation in much of the otherwise massive granites, gabbros, diabases, and other greenstones. The foliation of the granites shows that the pressure was exerted from a direction varying from west to south-west. Where massive beds of cherts and quartzites resisted the folding action, they with their associated beds of softer shales or slates have been shoved into ridges by overthrust faults, giving the hills cliff-faces inland, while their seaward slopes conform closely with the dip of the beds.

The gneisses seem to be metamorphic products of several rocks of different age and origin. Some of them probably represent part of the original Archæan complex; others may represent granites of a somewhat later date, injected into the first, but long anterior to the time of deposition of those sedimentary beds of Labrador that have been provisionally classed as Cambrian.

Glacial action has left its traces everywhere, the entire coast having at one time been covered by an ice-sheet sufficiently thick to override the highest hills.

A short chapter on the marine terraces which mark the limits of the subsidence of the land brings this interesting report to a close.

Dr. Bell's report (M), which follows, deals with the northern side of Hudson Strait. Baffin Land, a treeless region like that of the southern side of the strait, is made up principally of Laurentian rocks; a considerable area, however, of flat Silurian limestone borders the western shore in Fox Basin, and extends inland to Lake Nettilling. Satisfactory evidence is given of the occurrence of the Trenton and Utica formations, and it is stated on the authority of Professor Schuchert, of the United States National Museum, that the Baffin Land fauna had, like that of Manitoba, an early introduction of Upper Silurian.

It is added that among the Arctic islands northward of Baffin Land large areas of Upper Silurian rocks are known to occur associated with strata of Lower Silurian age.

Three appendices contain (1) observations of latitude made by Dr. Bell, (2) a list of plants collected by him in Hudson Strait, (3) a short list of Lepidoptera.

The scenic features of the country are, as usual in these reports, well brought out by photographic reproductions.

Dr. Hoffmann's report (R) of the section of Chemistry and Mineralogy consists of mineralogical notes and analyses of various ores, and of natural waters, also gold and silver assays.

Mr. E. D. Ingall contributes a report on mineral statistics and mines for 1898, which begins with a general table of the mineral production of Canada for a period of thirteen years, representing the work of the Mines Section of the Geological Survey. These statistics show that Canadian mining industry is in a very flourishing state.

The last eighteen pages of the volume are devoted to a very serviceable index in double columns. ARTHUR H. FOORD.

OBITUARY.

OTTO MARTIN TORELL.

(PLATE XV.)

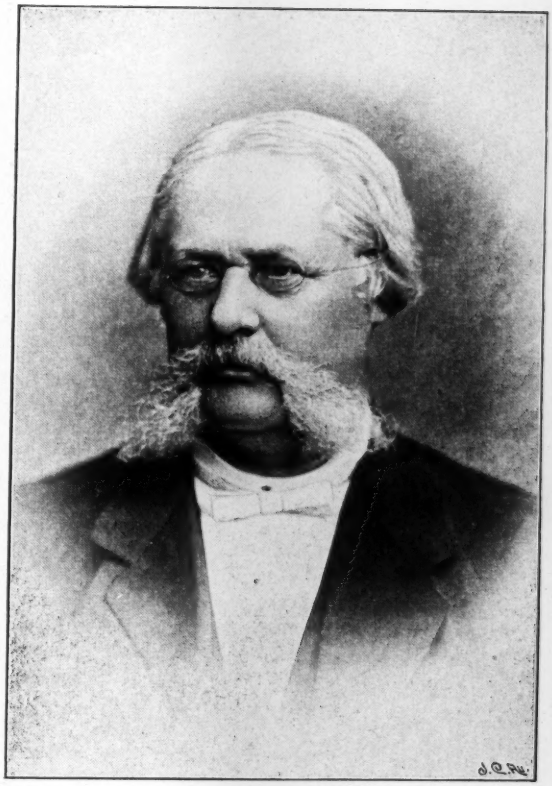
BORN JUNE 5, 1828. DIED SEPTEMBER 11, 1900.

THROUGH the kindness of Mr. Leonard Holmström, we are enabled to present our readers with an excellent portrait of the late Professor Torell, who from 1871 to 1897 was head of the Geological Survey of Sweden. The portrait originally accompanied a long article by Mr. Holmström in *Geologiska Foreningen i Stockholm's Förhandlingar* (xxiii, Häft 5) issued at the close of last year. Space does not permit us to publish even a condensation of this highly interesting account of the departed geologist, but Torell was known personally to so many of his colleagues in this country, which he frequently visited, that they will welcome some extracts therefrom.

Torell wrote little, partly from a disinclination for the mere physical act, partly from a striving after that completeness which can so rarely be attained, partly from a carelessness of personal fame, and partly perhaps because he was rather a propounder of new ideas than a patient elaborator of detail. His influence therefore on the geologists of the world was not quite so great as it might have been; but on those of his own country it was enormous. Mr. Holmström goes so far as to call him "in one sense *the creator of Swedish geology*. It is true that Sweden could show men eminent in that branch of learning before Torell's time, but it was not till his coming that geology was generally recognized as an independent science. He founded a school of geology in the University of Lund, which possessed neither professor, nor literature, nor collections for its study, and where even to-day there is no full professorship in the subject."

"He transformed the official Geological Survey of Sweden into a scientific institution of high rank. He himself was the founder of a truly scientific geology of the Quaternary period, through his genius and courage in championing the theory of a general glaciation of northern Europe, and for all time his name will be coupled with that bold hypothesis, which fought its way to victory in the teeth of contempt and official excommunication." On his first appearance before the German Geological Society, the geologists of Berlin could not listen to him with patience; but five years later they made him a chairman at their annual gathering.

It was in pursuit of evidence for or against his theory of an inland ice-sheet that he began the series of Arctic expeditions of which Sweden has such right to be proud, sacrificing to them no small part of his own means. A. E. Nordenskiöld, who was his companion, reminded us not long before his own death, that Torell's first expedition to Spitzbergen (1858) was made in an ordinary clinker-built fishing-smack, which leaked even before she left



Otto Torell.

Tromsö. Several of Torell's letters to Nordenskiöld are quoted by Mr. Holmström, and it is interesting to read the words: "for many years the quest of the Pole has been my *idée fixe*." None the less the Swedish expeditions have never been mere foolhardy or sensational attempts to beat the record of high latitude, but have borne that truly scientific character which Torell impressed on them from the first.

Instigated by Lovén, under whose penetrating influence he came at the age of 20, he undertook dredgings at Kristineberg, where now is the Swedish biological station, and it was here that he found *Yoldia arctica* in the fossil state. This discovery propounded the question as to the nature of former Arctic conditions in southern Scandinavia, which in after life he did so much to answer. At that time, however, the medical profession was his goal, and while conducting researches in comparative anatomy under Lovén, he also accompanied him on dredging expeditions in yet deeper waters, and accomplished much on his own account, especially on his journey to Iceland.

Whether as teacher at Lund, as friendly companion, or as head of an official establishment, Torell lost no opportunity of imparting some of his own enthusiasm to others, whether students, politicians, or wealthy landowners. He freed the Survey from the bonds of a rigorous officialdom, and encouraged the independent scientific work of the members of his staff in every possible way. But eager though he was to encourage science for its own sake, he was no less keen to apply it to the advantage of his native land. He conducted or instigated numerous surveys, both official and private, of the agronomic and technical geology of important districts. He founded the great cement industries of southern Sweden, bored for oil in the Silurian shales of Dalecarlia, showed the towns of Lund, Malmö, and Helsingborg how to get a constant supply of pure artesian water, helped to develop the sea-fisheries of Sweden, set on foot researches into the marl beds and phosphorite beds, and all materials suitable for the enrichment of the soil, fostered the building-stone industry, sought out uses for the vast deposits of peat, was a pioneer in the employment of water-gas, promoted railways to exploit the resources of northern Sweden, and toiled, albeit unsuccessfully, at the problem of extracting iron directly from the malm-ores.

Torell never became, as he intended and even wished, a practising physician. But he did not at first find the pursuit of pure science a satisfactory career, and in 1867 he even had thoughts of settling in England, which shows how bad things must have been with him. However, the appointment to the Geological Survey came at the right moment, and Sweden kept for herself one of her most eminent men of science and one of the most patriotic of her sons.

F. A. B.